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Preface

The Tata Energy Research Institute (TERI) has been producing this annual publication, the TERI Energy Data, Directory and Yearbook (TEDDY) since 1986, in response to a growing need for a comprehensive compilation of energy data and related information for India. Past issues of TEDDY have been very well received, and the 1989 issue met with such large demand that the entire print order ran out in a very short period. TEDDY has become a standard compilation which is used by researchers, energy related corporate organizations, Government departments, and a large number of other entities. We as the publishers of this volume have always attempted to seek views and ideas on how the usefulness of subsequent issues of TEDDY could be enhanced. This latest issue for 1990/91 incorporates several new features and additions which it is hoped would be of value to our readers and users. Also, in view of the fact that data and trend changes are not that rapid, it has been decided that TEDDY would be published every two years. The 1990/91 issue represents the first such that covers a period of two years.

TEDDY 1990/91 includes several new features. Some of these are (a) a comprehensive chapter on emissions of greenhouse gases and issues related to global warming; (b) inclusion of the iron and steel industry in coverage of the industrial sector and details of the potential for energy conservation in selected Indian industries; (c) financial performance of the state electricity boards, which has been provided in the chapter on power; (d) more detailed coverage of energy consumption in the residential and agricultural sectors; and (e) a revised format for presentation of tables and other information, which it is hoped would make this publication a little easier to read and use.

Several people have provided valuable inputs in the compilation of TEDDY, and it is very difficult to single out a few from the large number who have contributed. However, special mention must be made of the valuable contribution made by Mr P V Sridharan, Ms Preety Bhandari, Ms Amrita N Achanta, Mr H B Datta, Dr Chandra Shekhar Sinha, Ms Leena Srivastava, Mr Jami Hossain, Ms Smita Malhotra, Mr M Jayaraman, and Mr B Venkatakrishnan. The total work for TEDDY 1990/91 has been carried out under the guidance of Dr Ranjan K Bose and very ably handled by Ms Maithili Iyer. Staff in the Publications Unit and the Computer Centre provided very valuable support in producing the final output.

It would be of great value to my colleagues and I to receive any suggestions, comments or criticism that you might have to offer on this volume, and I would like to put forward the assurance that we will take them into account very seriously while bringing out the next issue.

Dr R K Pachauri
Director
Tata Energy Research Institute

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Energy - economy linkages

India in the world economy

India's performance has been fairly impressive with an annual GDP growth rate of 5.3% in the past decade. The Industrial and the Services sectors have contributed much to the overall GDP.

With the growth in the economy and increased mechanisation of agriculture and allied activities, the commercial energy consumption has also gone up. It can be observed that in 1965, India's per capita commercial energy consumption was only 9% of the world average, which has moved up to 18.5% in 1989. If we look at the per capita commercial energy consumption, we see that, our consumption figures are rather low. One of the reasons is that these figures do not include the traditional energy, which forms a large part of India's total energy consumption.

Table I.1
Average annual growth rates.

	1965-80 (%)	1980-89 (%)
GDP	3.6	5.3
Agriculture	2.5	2.9
Industry	4.2	6.9
Services etc.	4.4	6.5

Source: World Bank, World Development Report, 1990.

Table I.2
Commercial energy consumption.

	Consumption per capita (kgoe)		Growth rate (%)	
	1965	1989	1965	1989
India	100	226	5.8	6.1
Pakistan	135	213	3.5	6.2
Brazil	286	897	9.9	4.5
China	178	591	9.8	5.5
France	2468	3778	3.7	0.7
U.S.A	6535	7794	2.3	1.0
Japan	1474	3484	6.1	2.3
World	1146	1222	4.1	2.1

Source: World Bank, World Development Report, 1990.

Economic growth trends

Total gross domestic product (GDP) has grown from Rs.1224.3 billion in 1970/71 to Rs.1974.2 billion (1980/81 prices)in 1989/90. This corresponds to a rise in per-capita GDP of over 40% during the seventeen year period, and an annual average growth rate of 5.5%. Sectoral composition of GDP (at factor cost) has also changed significantly during this period, and may be summarized as follows:

(i) the relative share of the primary production sector (including agriculture, forestry, logging, mining and quarrying) reduced from 40% to about 34%;

(ii) the share of the secondary producing sector (comprising manufacturing industry, construction, and electricity/gas/water supply) showed a distinct though gradual increase from 24% to about 27%;

(iii) there was a marginal rise in the share of the transportation, communication and trade sector, from 17% to 18.3%; and

(iv) there was a substantial increase in the share of the services/commercial sector from less than 19% to 20.9%.

These changes at the aggregate sectoral level (Fig.1) were accompanied by several compositional changes within each sector. Perhaps the most notable trends include increasing mechanization of agriculture and increasing cultivation of high yielding variety (HYV) crops; a diversification away from primary and energy-intensive manufacturing industries; a decline in the share of passenger and freight traffic carried by the railways, and so forth. Such trends have resulted in substantial changes in the energy demand mix.

Energy and economic growth

Fig. 2 shows an upward trend in the overall commercial energy consumption intensity in the Indian economy. There is a gradual increase in the commercial energy intensity in agriculture too. This reflects the trend towards mechanization of Indian agriculture---both for land preparation and for lift irrigation Although agriculture is still not a major commercial energy consumer at the national level, it may account for a significant share of commercial energy consumption in certain states, and at least in certain seasons.

The industrial sector continues to be the single largest commercial energy consuming sector, although its share has declined gradually (fig.3). Its commercial energy consumption intensity has also declined over the past decade or more, due largely to a relatively rapid expansion of non-energy intensive industries. However, the adoption of new (inherently more energy efficient) technologies for certain industrial processes, and the successes at implementing energy conservation measures in certain industrial units, may also be significant factors.

Commercial energy intensity of the transport sector has also increased since the early 1970s. A fall in the share of traffic handled by the railways is the major reason. Goods

have been carried over increasingly longer distances by trucks. For passenger transport, the growth of public modes (buses and mini-buses) has not kept pace with the rise in the more energy intensive mechanized private modes (cars/taxis and 2/3 wheelers). It may be noted that rail and road still continue to account for more than 90% of the total traffic carried.

Energy demand and supply

Although traditional energy fuels (fuelwood, crop-residues and animal wastes) are estimated to account for over 50% of the total final energy consumption in the country, the available data-base is very sparse. It is for this reason alone, that information presented in the energy supply section does not include the use of traditional energy forms.

According to one estimate of non-commercial energy consumption[1], it increased from about 143 million tonnes of oil equivalent (mtoe) in 1972/73 to 161 mtoe in 1982/83. In percentage terms however, its share declined from about 74% to 66% during the ten year period (Fig.4). A large portion of traditional fuels are used rather inefficiently in rural households for cooking, water heating and space heating.

The supply and sales/consumption data for commercial energy forms are relatively well documented. Fig.5 shows the rise in commercial energy consumption since 1980/81. In terms of calorific content, direct use of coal (i.e. excluding coal used for thermal power generation) still accounts for nearly 50% of total commercial energy consumption, and petroleum products for nearly 40%. However, despite the fact that investment (in real terms) in the coal, hydrocarbon and power sectors has nearly quadrupled since 1974/75, shortages still continue.

Owing to persistent shortages of coal and power supplies during the past decade, the consumption of petroleum products increased more rapidly than was anticipated; the reason being that oil can be imported relatively more easily to help overcome energy shortages in the short term. In fact, diesel oils are largely used to mitigate the effects of a power shortage; while fuel oils may be used in industrial boilers in times of a scarcity of coal supplies. It is owing to power shortages and a variety of other reasons (increased use of diesel trucks, dieselization of the railways, a subsidy on kerosene, and so forth), that the share of middle-distillates in the petroleum products consumption mix has increased (Fig.6).

The power supply utilities have responded to the power shortage situation by preferring to invest in thermal power stations, whose gestation period is usually less than that of hydro power stations. Consequently, the share of hydro capacity and hydro generation have decreased gradually over the past decade or so (Fig.7). Although coal

[1] R. Bhatia,"Energy Demand Management Policies in India", the Asian Development Bank, Energy Study Series No.5, 1986.

supplies have increased substantially in recent years (after a period of stagnation during the mid- and late-1970s), shortages still exist. The main reason is that even though, with the increase of open-cast mining, coal extraction rates and output per man-shift (OMS) have gone up; the ash content also has. Comparatively larger quantities of coal are now needed to meet a certain requirement, than was the case a decade ago. Therefore, coal transport requirements have increased; and owing to transportation bottlenecks, pit-head stocks have risen while shortages continue to exist in areas away from coal fields.

Energy prices

Energy prices in India are administered, with the goal of pursuing certain social objectives. They do not, in general, reflect costs. The price paths of kerosene and petrol serve to illustrate this point. Kerosene is heavily subsidised, because it caters to the energy needs of the lower income households in rural as well as urban areas.

Similarly, electricity tariffs are also lower than supply costs -- this is particularly true regarding electricity sales to rural agricultural farmers, for whom the tariffs are lowest (compared to other categories of consumers), while the costs borne by power utilities for supplying them power may well be the highest. These low tariffs have contributed significantly to losses of the state electric utilities.

It is therefore clear that a rational energy pricing policy is very important for the purposes of long term energy planning.

Energy balance

Table I.3 through I.12 show commercial energy balances for 1980/81 through 1989/90 respectively. Owing to scarcity of reliable data on the supply and consumption of traditional fuels, production, imports/exports, stock changes, conversion losses, the net availability and sectoral consumption of commercial energy only is considered. All data are presented in common units of million tonnes of oil equivalent or mtoe (where 1 toe=10.2 million kCal). The conversion factors for the various energy fuels to mtoe are given at the end of the chapter.

Several assumptions have been made in compiling these energy balances. For instance, the same average calorific value of coal has been used for conversion of coal tonnage to mtoe units, although it is known that with increase in the share of open-cast mining that has taken place in the 1980s, the average calorific value may have reduced. This assumption is made for lack of detailed data on even the average calorific content of various grades of coal that are mined each year. Furthermore, the discrepancy between claims of quality of coal despatched and that received by certain major consumers (particularly industry) has also not been accounted for. It is assumed that the average calorific value of steel grade coal supplied for thermal power generation is 4000 kCal/kg. As the tonnage of coal supplied to the power sector is also known, we have enough information to compute the mtoe of coal supply to this sector. Likewise for the transport

sector (railways), where tonnage is known and the calorific content is assumed (4000 kCal/kg). With this information, the mtoe value of coal used in other sectors is determined.

As with coal, it becomes necessary to make some assumptions regarding calorific content of natural gas. Here, the standard norm of 856.8 toe/mcm of gas, as adopted by the oil industry, is used. However, this does not pertain to lean gas (after LPG extraction). To estimate the mtoe value of gas after LPG extraction, the product of tonnage of LPG and calorific value of LPG is subtracted from the overall natural gas mtoe value. Owing to differences in LPG extraction quantities from year to year, this procedure gives a different value each year for average calorific value of gas remaining after LPG shrinkage.

In the power sector, it is assumed (for sake of consistency) that the power generation conversion efficiency of hydro and nuclear power plants is the same as that for coalbased thermal power plants. This is a standard practice for constructing energy balance tables. The auxiliary consumption of various types of power generating plants are assumed to be as follows: (i) 10% of gross generation for coal based thermal and nuclear power stations; (ii) similarly, 10% for diesel power plants; (iii) 2% for gas turbine units; and (iv) 0.5% for hydropower plants.

These norms are average figures observed empirically from past data. The use of petroleum products for power generation is as given in official statistics of the Department of Petroleum and Natural Gas.

Not all soft-coke and kerosene are consumed by the residential sector. They are also consumed for other energy uses. However, such disaggregate data is not available. The National Council of Applied Economic Research (NCAER), India, has conducted a detailed survey in 1978/79, the results of which indicated that about 37% of total soft coke and a little over 16% of kerosene is consumed by commercial establishments. The same norms have been assumed in the energy balances.

As for stock changes, data are available only for the coal sector. Similar data are not available for crude oil and refined products. Therefore, estimates for changes in stocks of these items represent indigenous production plus imports minus exports minus sales/consumption. The estimates for stock changes that have been so derived give no indication of the actual stock levels.

Total commercial energy supplies (net of changes in stocks) in India increased from about 92.6 mtoe in 1980/81 to 174.7 mtoe in 1989/90 at the rate of about 7.4% per annum. During the same time period, indigenous production of commercial energy increased from about 72.6 mtoe to over 152 mtoe, at the rate of over 8.6% per annum. The share of indigenous production of commercial energy (in the total commercial energy availability mix) therefore increased from 78.6% in 1980/81 to about 87% in 1989/90.

Much of this increased production was in the form of fossil fuels: coal, oil and natural

gas. Coal production increased from an estimated 56 mtoe in 1980/81 to over 98 mtoe in 1989/90, as opencast mining increased and new mining techniques were introduced. Larger and more powerful equipment (shovels, draglines, dumpers etc.) are now being deployed to permit opencast mining up to a depth of as much as 500 metres. However, with the increase in opencast mining, the average quality of mined coal has deteriorated.

The increase in oil and gas production was due largely to the accelerated development of the Bombay High Offshore basin. Crude oil production more than quadrupled during the ten year time period, from about 10.5 in 1980/81 to nearly 34.1 mt in 1989/90. Gross natural gas production increased phenomenally from 2358 million cubic metres (mcm) or 2.02 mtoe in 1980/81 to 16989 mcm (14.557 mtoe) in 1989/90. A significant part of the natural gas produced however, continues to be flared because of several reasons. Delays in commissioning downstream gas utilization facilities is only one factor. There is apparently little flexibility in reducing the production of associated gases, which will be possible only if oil production is also limited -- but which may lead to a higher oil import bill. It is possible to limit the production of gas only from those fields which have non-associated gas reserves (e.g. South Basin): the production rate from such fields may be adjusted to the extent gas can be utilized purposefully downstream. Gas flaring has increased from 769 mcm in 1980/81 to 5721 mcm in 1989/90.

Nuclear power generation also increased marginally after 1980/81 as a 2x235 MW nuclear station was commissioned in Kalpakkam (Tamil Nadu). Primary nuclear generation increased from 0.253 mtoe in 1980/81 to 0.39 mtoe in 1989/90. Similarly, primary hydroelectricity generation also increased from 3.9 mtoe to over 5 mtoe during the same time period.

India continues to be a net energy importer, net crude oil and petroleum product imports in 1989/90 being 22.13 mtoe (during 1980/81, the net imports were over 23 mtoe). Imports of superior grade coal were about 0.735 mtoe in 1980/81, and gradually increased to 2.161 mtoe in 1989/90. As a percentage of foreign exchange earnings through commodity exports, India's net oil imports reduced from about 78% in 1980/81 to about 21% in 1989/90. This is due largely to: (i) a rapid increase in indigenous crude production, at least until 1984/85, when nearly 29 mt were produced; and (ii) generally soft oil prices in the international market, particularly after 1986. However, the outlook for a further rapid increase in indigenous crude production, as witnessed during 1980/81 to 1984/85 period, is not very encouraging -- in fact, crude oil production has more-or-less stablized at about 33 mt per annum since 1984/85.

Net availability of commercial energy for final consumption increased from about 68 mtoe in 1980/81 to over 117 mtoe in 1989/90, at the rate of 6.2% per annum. Energy lost in conversion processes (power generation, oil refining, soft-coke production etc.) increased from about 24.1 mtoe to nearly 58 mtoe during the same time period.

The final consumption pattern for 1980/81 through 1989/90, shown in Table I.3 through I.12 is based on official estimates of sectoral energy consumption, as published

in various official statistical statements of the Government of India. Although there may be significant shortcomings in the consumption pattern (such as split between HSD/LDO consumption between transport and agriculture sectors) the data presented do highlight some important aspects. For instance, including the use of coal, naphtha and natural gas as feedstock, it is evident that the industrial sector is the major commercial energy consuming sector. During 1980/81, it accounted for about 35.8 mtoe or 52.4% of total final consumption. The corresponding figures for 1989/90 were 60.495 mtoe and 50.7% respectively.

It is known that the transport sector is a major oil consuming sector. It is estimated that HSD/LDO and petrol consumption increased from 12.62 mtoe in 1980/81 to 25 mtoe in 1989/90. Transport sector accounted for about 43% of total consumption of petroleum products in 1980/81, and its share rose to over 47% in 1989/90. The agricultural, residential and other sectors do not appear to be major commercial energy consumers. It is important to realize however, that if the role of traditional fuels and draught animal power are also considered, sectoral shares of (total) final energy consumption are considerably different.

Fig.1. Sectoral composition of GDP

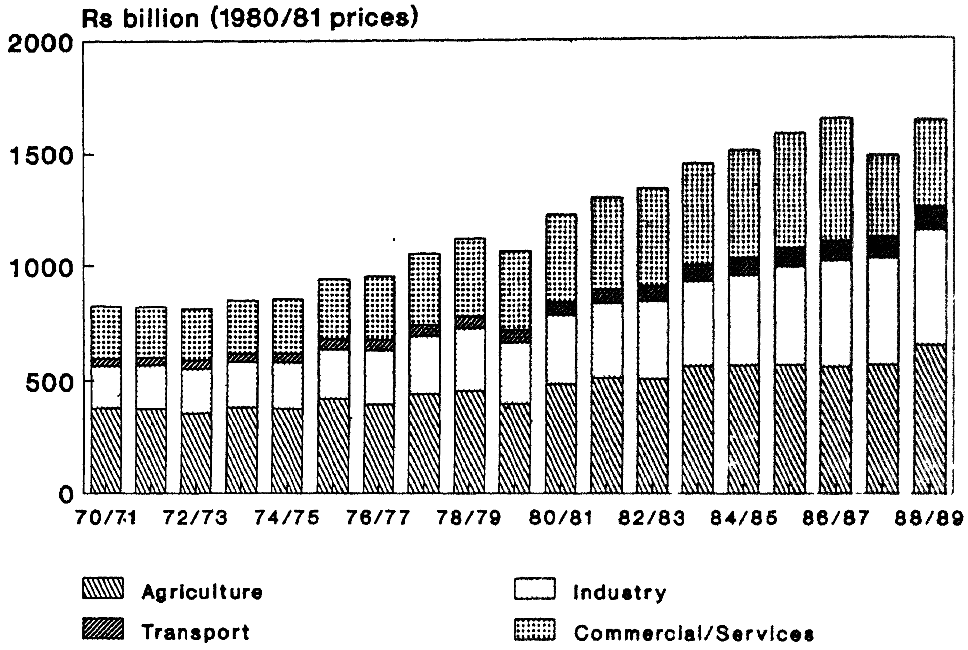


Fig 2. Commercial energy consumption intensity

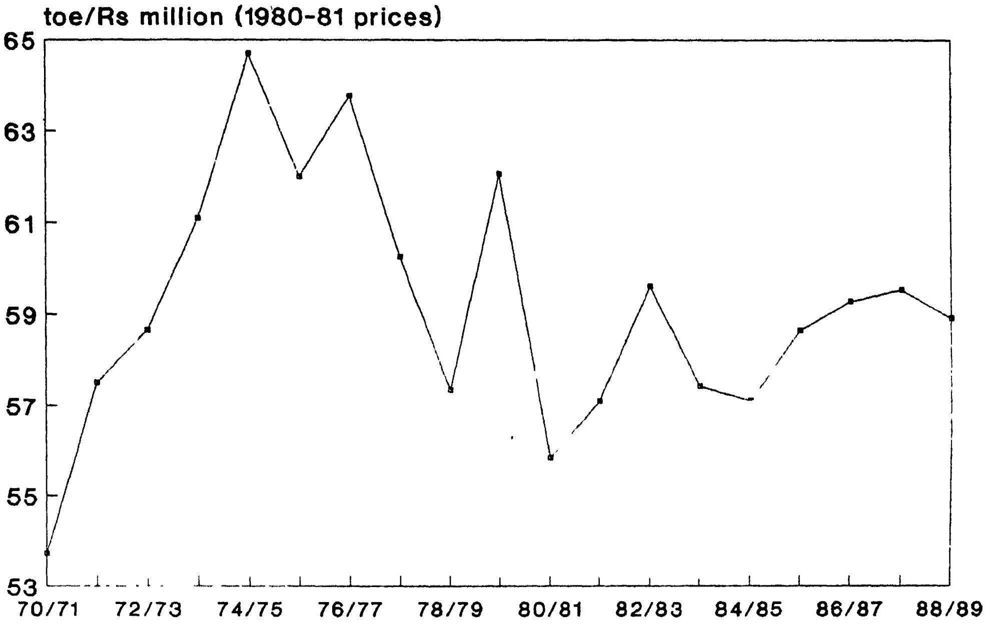


Fig. 3. Sectoral consumption of commrecial energy

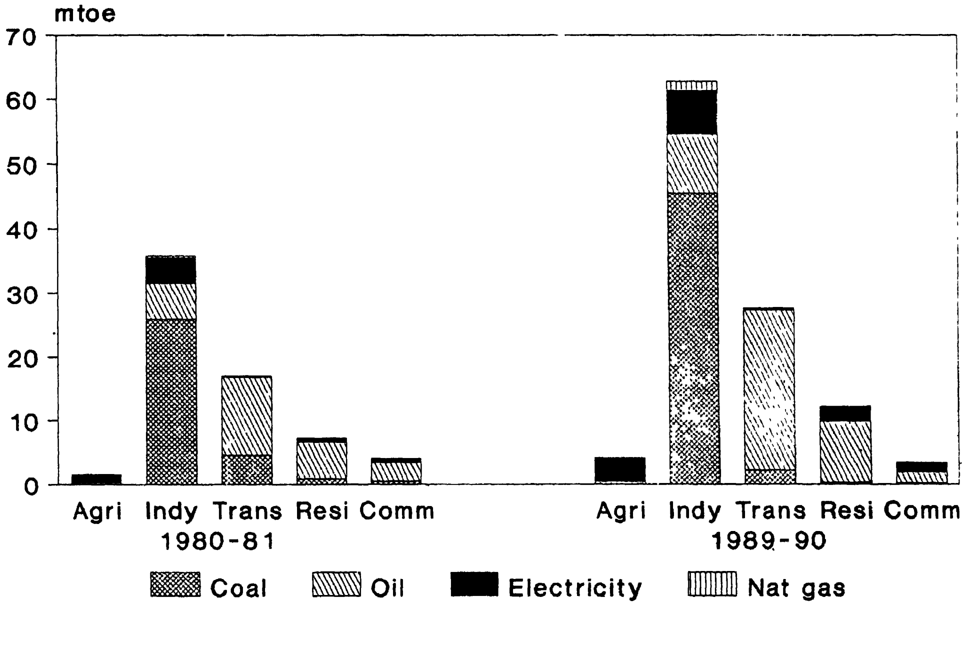


Fig.4. Trends in consumption of commercial and traditional energy

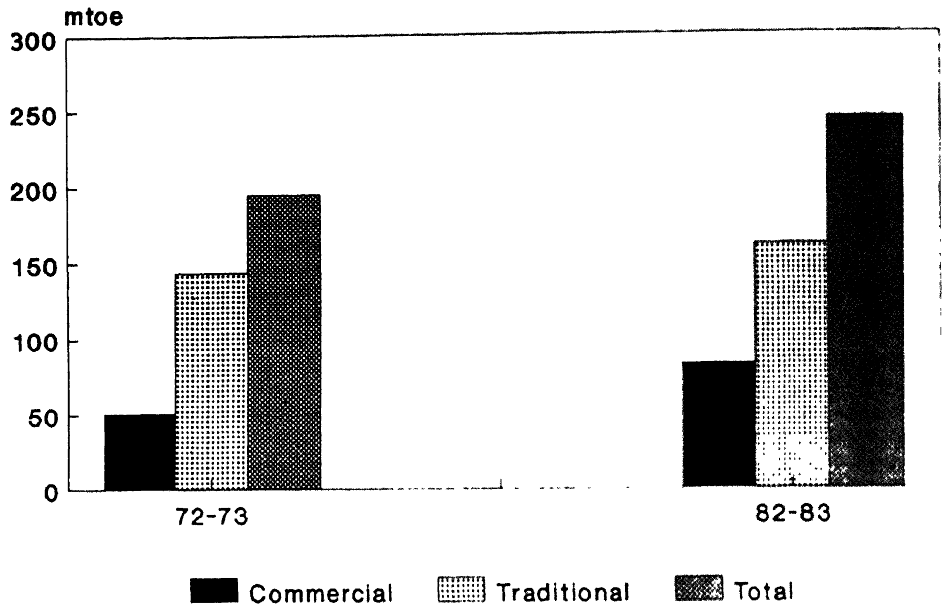


Fig.5. Trends in commercial energy consumption

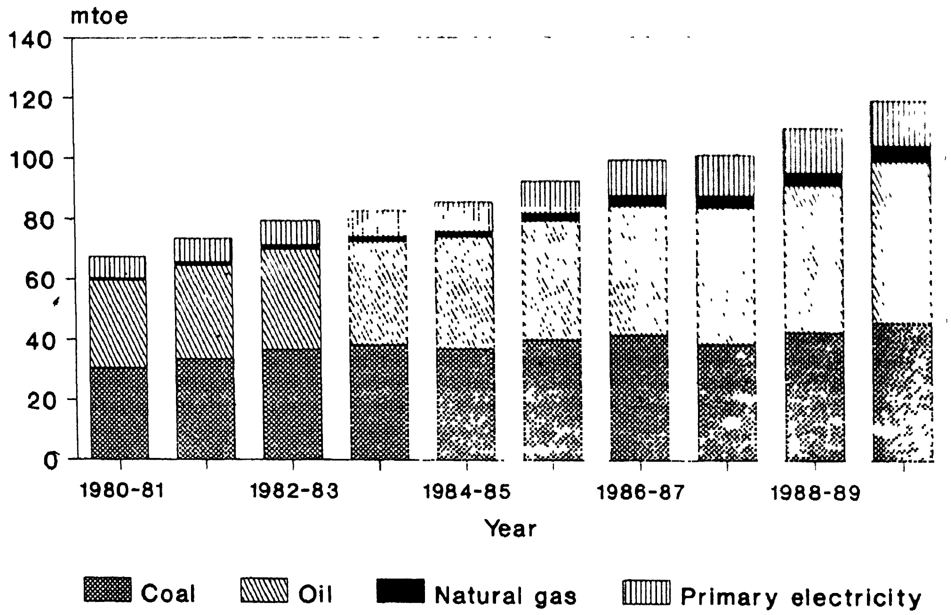


Fig.6. Trends in sales of petroleum products

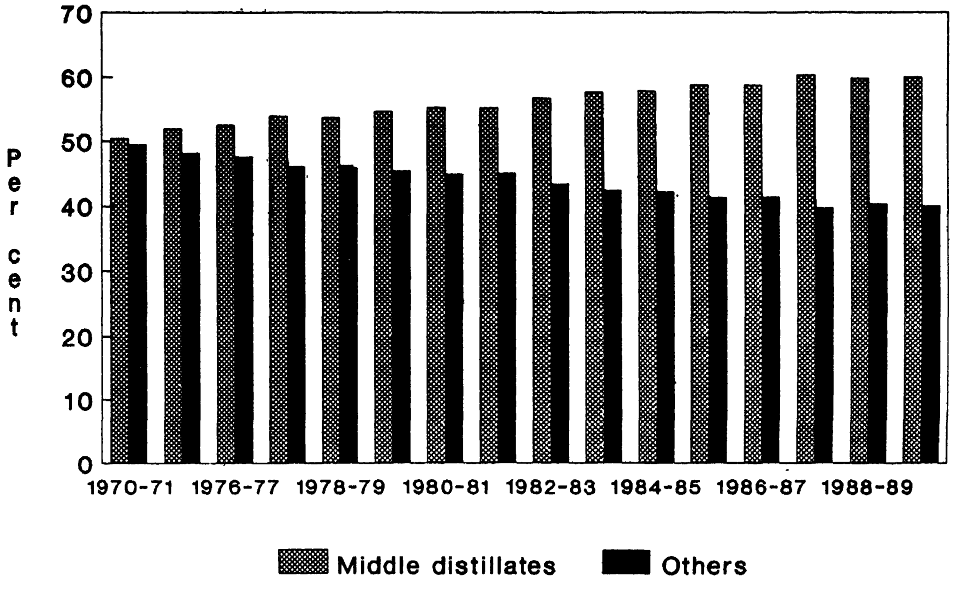


Fig.7. Share of hydroelectric power

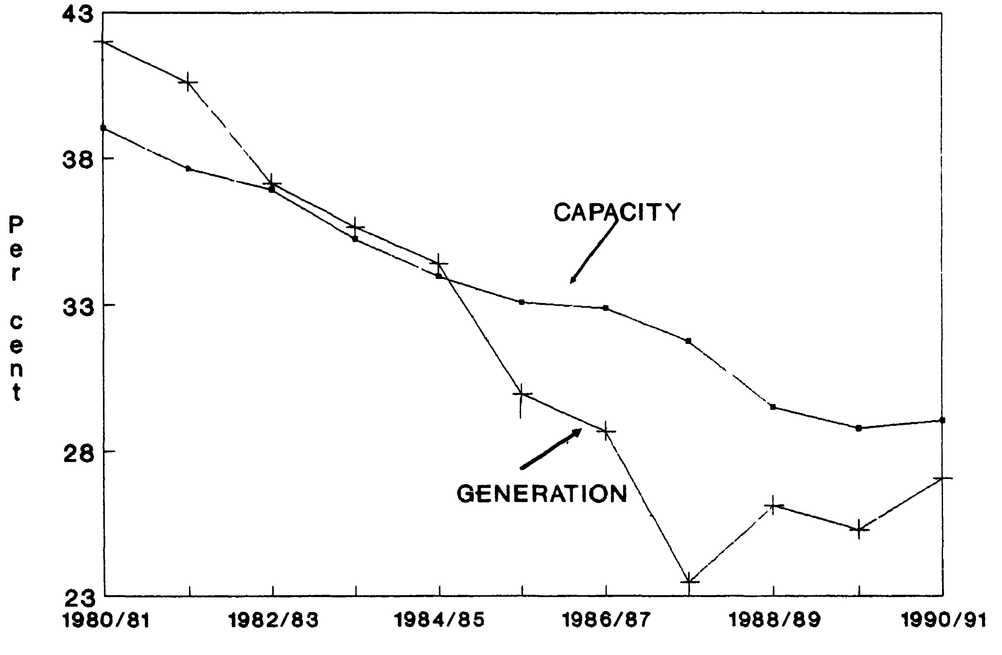


Table I.3

Commercial energy balance for India(1980/81)

(mtoe)

	Primary energy							Sec-
	Coal	**Crude**	**Natural gas**	**Hydro power**	**Nuclear power**	**Soft coke**	**LPG**	**Naphtha**
Supply								
Production	55 89	10 507	2 02	3 928	0 253	.	.	
Imports	0 735	16 248	.	.		.	.	0 248
Exports	0 054	.	.	.	.	.	.	0 038
Stock changes	2 944	0 919	.	.	.	.	( ) 044	( )0 226
Availibility	**53.627**	**25.836**	**2.02**	**3.928**	**0.253**	.	**0.044**	**0.226**
Conversion	**(-)23.198**	**(-)25.836**	**(-)1.137**	.	.	**1.234**		**2 273**
Soft coke	(-)1 395	.	.	.	.	1 234		
Petroleum refining	.	25 836	.	.	.	.	(413	2 273
LPG extraction			.					
Power generation	21 803		0 421	3 928	0 253			
Conversion losses	(-)14.535	.	**(-)0.299**	**(-)2.619**	**(-)0 169**	.	.	.
Aux cons in power station	( )0 726		(-)0 002	(-)0 019	( )0 008			
T/D losses	.							
Natural gas flaring etc		.	0 716			1 234		
Net availibility	30.429	.	0.883	.	.	1.234		**2 499**
Consumption	30.429	.	0.883	.	.	1.234		**2.499**
Agriculture			0 039					
Industry	25 798*		0 29				0 064	
Transport	4 631	.	.					
Residential			0 012			0 771		
Other energy uses					.	0 463		
Non energy uses			0 542		.	.		2 499

* Includes coking coal use and coal used as feed stock

[a] T/D losses not accounted for

ondary energy										
Mogas	**ATF**	**Kero-sene**	**HSD**	**LDO**	**Fuel oils**	**Other pet pdts**	**Total pet pdts**	**Thermal power**	**Total power**	**Total energy**
-	-	-	-	-	-	-	-	-	4.181	72.598
-	0.034	2.157	3.331	0.07	1.316	0.324	7.48	-	-	24.463
-	-	-	-	-	-	-	0.038	-	-	0.092
(-)0.003	(-)0.098	0 242	0.253	0.056	(-)0.016	.109	0.483	-	-	4.346
0.003	**0.132**	**1.915**	**3.078**	**0.014**	**1.332**	**0.215**	**6.959**	-	-	**92.623**
1.625	**1.066**	**2.503**	**7.428**	**0.983**	**3.974**	**2.041**	**22.306**	**17.253**	**20.068**	**(-)23.859**
-	-	-	-	-	-	-	-	-	-	(-)0.161
1 625	1 066	2 503	7 629	1 147	6 028	2.041	24.725	-	-	(-)1.111
-	-	-	-	-	-	-	-	-	-	-
-	-	-	0.201	0 164	2.054	-	2 419	24.643	28.824	28.824
-	-	-	**(-)0.134**	**(-)0.109**	**(-)1.369**	-	**(-)1.612**	**(-)16.416**	**(-)19.234**	**19.234**
-	-	-	(-)0.006	(-)0 00	(-)0.068	-	(-)0.079	(-)0.807	(-)0.834	(-)0.834
-	-	-	-	-	-	-	-	-	(-)1.803	(-)1.803
-	-	-	-	-	-	-	-	-	-	(-)0.716
1.628	**1.198**	**4.418**	**10.506**	**0.997**	**5.306**	**2.256**	**29.265**	**7.39[@]**	**6.953**	**68.764**
1.628	**1.198**	**4.418**	**10.506**	**0.997**	**5.306**	**2.256**	**29.265**	-	**6.953**	**68.764**
-	-	-	0 104	0 039	0 22	-	0.363	-	1.223	1.625
-	-	-	1 035	0 865	4 751	-	6.715	-	4.058	36.861
1.628	1 198	-	9 367	0 093	0 335	-	12.621	-	0.191	17.443
-	-	3 703	-	-	-	-	4.073	-	0.781	5.637
-	-	0 715	-	-	-	-	0.738	-	0.7	1.901
-	-	-	-	-	-	2.256	4.755	-	-	5.297

Table I.4
Commercial energy balance for India (1981/82)
(mtoe)

	Primary energy							Sec-
	Coal	**Crude**	**Natural gas**	**Hydro power**	**Nuclear power**	**Soft coke**	**LPG**	**Naphtha**
Supply								
Production	**61.24**	**16.194**	**3.299**	**4.184**	**0.255**	-	-	-
Imports	0.318	15 298	-	-	-	-	-	0 122
Exports	0 078	0 838	-	-	-	-		0 059
Stock changes	2 157	0 508	-	-	-	-	(-)0 01	0 107
Availibility	**59.323**	**30.146**	**3.299**	**4.184**	**0.255**	**1.242**	**0.01**	**(-)0.044**
Conversion	**(-)25.95**	**(-)30.146**	**(-)1.988**	-	-	-	**0.545**	**3.229**
Soft coke	1 403	-	-	-		1 242		
Petroleum refining	-	30 146	-		-	-	0 463	3 229
LPG extraction	-	-	0 082		-	-	0 082	
Power generation	24 547	-	0 51	4 184	0 255			
Conversion losses	(-)16 365	-	(-)0 362	(-)2 789	(-)0 170	-		
Aux cons in power station	(-)0 818	-	( )0 003	(-)0 007	( )0 008			
T/D losses	-	-			-			
Natural gas flaring etc	-		(-)1 396			-		
Net availability	**33.373**	-	**1.311**	-	-	**1.242**	**0 555**	**3.185**
Consumption	**33.373**	-	**1.311**	-	-	**1.242**	**0.555**	**3.185**
Agriculture	-		0 039					
Industry	28 958*	-	0 411	-	-		0 057	
Transport	4 415	-		-		-		
Residential	-	-	0 012		-	0 776	0 479	
Other energy uses				-		0 466	0 019	
Non energy uses	-		0 849			-		3 185

* Includes coking coal use and coal used as feed stock
@ T/D losses not accounted for

ondary energy										
Mogas	**ATF**	**Kero-sene**	**HSD**	**LDO**	**Fuel oils**	**Other pet pdts**	**Total pet pdts**	**Thermal power**	**Total power**	**Total energy**
-	-	-	-	-	-	-	-	-	4.439	85.172
-	0.117	2.057	1.902	0 086	0.519	0.233	5.036	-	-	20.652
-	-	-	-	-	-	-	0.059	-	-	0.975
0 017	(-)0 01	0 191	0 049	(-)0.04	0.247	0.186	0.773	-	-	3.438
(-)0.017	**0.127**	**1.866**	**1.853**	**0.09**	**0.272**	**0.047**	**4.204**	-	-	**101.411**
1.727	**1.074**	**3.038**	**9.175**	**0.798**	**5.066**	**2.445**	**27.097**	**19.022**	**23.984**	**(-)26.567**
-	-	-	-	-	-	-	-	-	-	(-)0.161
1 727	1 074	3 038	9 358	0 982	6 804	2 445	29.12	-	-	(-)1.026
-	-	-	-	-	-	-	-	-	-	-
-	-	-	0.183	0 184	1.738	-	2.105	27.162	31 601	31.601
-	-	-	**(-)0.122**	**(-)0.123**	**(-)1.159**	-	**(-)1.404**	**(-)18.131**	**(-)21.090**	**(-)21.09**
-	-	-	(-)0 006	(-)0 006	(-)0.058	-	(-)0.07	(-)0 891	(-)0 906	(-)0.906
-	-	-	-	-	-	-	-	-	(-)1.988	(-)1.988
-	-	-	-	-	-	-	-	-	-	(-)1.396
1.71	**1.201**	**4.904**	**11.028**	**0.888**	**5.338**	**2.492**	**31.301**	**8.140@**	**7.617**	**74.844**
1.71	**1.201**	**4.904**	**11.028**	**0.888**	**5.338**	**2.492**	**31.301**	-	**7.617**	**74.844**
-	-	-	0 101	0 031	0.17	-	0 302	-	1.283	1 624
-	-	-	1 089	0 757	4 856	-	6.759	-	4.479	40.607
1 71	1 201	-	9 838	0 1	0 312	-	13.161	-	0.211	17.787
-	-	4 11	-	-	-	-	4.589	-	0 881	6 258
-	-	0 794	-	-	-	-	0.813	-	0 763	2.042
-	-	-	-	-	-	2 492	5 677	-	-	6.526

Table I.5
Commercial energy balance for India (1982/83).
(mtoe)

	Primary energy							Sec-
	Coal	Crude	Natural gas	Hydro power	Nuclear power	Soft coke	LPG	Naphtha
Supply								
Production	73.818	21.063	4.229	4 083	0 171	.	.	.
Imports	0.97	16.949	.	.	.	.	.	0 108
Exports	0.073	4 552	.	.	.	.	.	0 103
Stock changes	10 907	0 304	.	.	.	.	(-)0 029	0 035
Availability	**63.808**	**33.156**	**4.229**	**4.083**	**0.171**	.	**0.029**	**(-)0.03**
Conversion	**(-)27.08**	**(-)33.156**	**(-)2.727**	.	.	**0.997**	**0.65**	**3.21**
Soft coke	1 127	.	.	.	.	0 997	.	.
Petroleum refining	.	33 156	.	.	.	.	0 459	3 21
LPG extraction	.	.	0 191	.	.	.	0 191	.
Power generation	25 953	.	0 84	4 083	0 171	.		
Conversion losses	(-)17 302	.	(-)0 596	(-)2 722	(-)0 114	.		.
Aux cons in power station	(-)0 865	.	(-)0 005	(-)0 007	(-)0 006			
T/D losses	.	.		.	.	.		
Natural gas flaring etc	.	.	1 696	.	.	.		.
Net availability	**36.728**	-	**1.502**	.	-	**0.997**	**0.679**	**3.18**
Consumption	**36.728**	-	**1.502**	.	-	**0.997**	**0.679**	**3.18**
Agriculture	.	-	0 042	.	.	.	.	.
Industry	32 434*	.	0 479	.	.	.	0 06	.
Transport	4.294		.		.	.		
Residential	. .		0 011	.	.	0 623	0 599	
Other energy uses	.		.	.	.	0 374	0 02	
Non energy uses	.		0.97	.	.			3 18

* Includes coking coal use and coal used as feed stock
@ T/D losses not accounted for

ondary energy										
Mogas	**ATF**	**Kero-sene**	**HSD**	**LDO**	**Fuel oils**	**Other pet pdts**	**Total pet pdts**	**Thermal power**	**Total power**	**Total energy**
-	-	-	-	-	-	-	-	-	4.254	103.364
-	0.26	1.965	2.672	0.019	-	0.193	5.217	-	-	23.136
-	-	-	0.022	-	0.667	-	0.792	-	-	5.417
0.08	0.251	0.062	0.319	0.075	(-)0.014	0.07	0.849	-	-	12.06
(-)0.08	**0.009**	**1.903**	**2.331**	**(-)0.056**	**(-)0.653**	**0.123**	**3.576**	-	-	**109.023**
1.922	**1.21**	**3.545**	**9.868**	**0.936**	**5.851**	**0.407**	**29.599**	**20.423**	**25.429**	**(-)28.552**
-	-	-	-	-	-	-	31 859	-	-	(-)0.13
1.922	1.21	3.545	10.102	1 16	7.844	2.407	-	-	-	(-)1 297
-	-	-	-	-	-	-	2.451	29.244	33.498	-
-	-	-	0.234	0.224	1.993	-	(-)1.634	(-)19.532	(-)22.368	33.498
-	-	-	**(-)0.156**	**(-)0.149**	**(-)1.329**	-	**(-)0.021**	**(-)0.891**	**(-)0.904**	**(-)22.368**
-	-	-	(-)0.008	(-)0.007	(-)0.006	-	-	-	(-)2.157	(-)0.904
-	-	-	-	-	-	-	-	-	-	(-)2.157
-	-	-	-	-	-	-	-	-	-	(-)1 696
1.842	**1.219**	**5.448**	**12.199**	**0.88**	**5.198**	**2.53**	**33.175**	**8.821**[@]	**8.069**	**80.471**
1.842	**1.219**	**5.448**	**12.199**	**0.88**	**5.198**	**2.53**	**33.175**	-	**8.069**	**80.471**
-	-	-	0.118	0.028	0.169	-	0.315	-	1.504	1.861
-	-	-	1.314	0 75	4.717	-	6.841	-	4 471	44.225
1 842	1.219	-	10 767	0.102	0.312	-	14.242	-	0.222	18.758
-	-	4 566	-	-	-	-	5.165	-	1 021	6.82
-	-	0 882	-	-	-	-	0 902	-	0 851	2.127
-	-	-	-	-	-	2.53	5.71	-	-	6.68

Table I.6
Commercial energy balance for India (1983/84)
(mtoe)

	Primary energy							Sec-
	Coal	**Crude**	**Natural gas**	**Hydro power**	**Nuclear power**	**Soft coke**	**LPG**	**Naphtha**
Supply								
Production	67 764	26 02	5 108	4 217	0 299			
Imports	0 225	15 967	·	·				0 138
Exports	0 039	5 522	·	·	·			0 968
Stock changes	0 651	1 202	·	·			( )0 01	0 002
Availability	**67.299**	**35 263**	**5.108**	**4.217**	**0.299**	·	**0.01**	**(-)0.832**
Conversion	**(-)29.086**	**(-)35.263**	**(-)3.44**	·	·	**0.857**		**3.846**
Soft coke	0 969	·		·	·	0 857		
Petroleum refining	·	35 263	·				0 581	3 846
LPG extraction	·	·	0 252	·	·		0 252	
Power generation	28 117	·	0 993	4 217	0 299			
Conversion losses	(-)18 745		( )0 705	(-)2 811	( )0 199			
Aux cons in power station	(-)0 937	·	( )0 006	(-)0 007	(-)0 01			
T/D losses	·		·					
Natural gas flaring etc	·		2 195					
Net availability	**38.213**	·	**1.668**	·	·	**0 857**		**3 014**
Consumption	**38.213**	·	**1.668**	·	·	**0 857**	**0 843**	**3 014**
Agriculture	·		0 046					
Industry	34 017*	·	0 527	·			0 073	
Transport	4 196	·	·					
Residential	·	·	0 013			0 536		
Other energy uses			·			0 321		
Non energy uses	·	·	1 082					3 014

* Includes coking coal use and coal used as feed stock
T/D losses not accounted for

ondary energy										
Mogas	**ATF**	**Kero-sene**	**HSD**	**LDO**	**Fuel oils**	**Other pet pdts**	**Total pet pdts**	**Thermal power**	**Total power**	**Total energy**
-	-	-	-	-	-	-	-	-	4.516	103.408
-	0.18	2.121	1.869	0.043	-	0.146	4.497	-	-	20.689
-	-	-	0.059	-	0.043	0.071	1.141	-	-	6.702
0.049	0.275	(-)0.136	0.243	0.205	0.281	(-)0.311	0.598	-	-	2.451
(-)0.049	(-)0.095	**2.257**	**1.567**	**(-)0.162**	**(-)0.324**	**0.386**	**2.758**	-	-	**114.944**
2.072	**1.381**	**3.515**	**11.324**	**1.07**	**5.577**	**1.93**	**31.548**	**22.19**	**27.555**	**(-)31.261**
-	-	-	-	-	-	-	-	-	-	(-)0.112
2.072	1 381	3.515	11.474	1 297	7.768	1.93	33.864	-	-	(-)1.399
-	-	-	-	-	-	-	-	-	-	-
-	-	-	0.15	0.227	2.191	-	2.568	31.678	36.194	36.194
-	-	-	**(-)0.100**	**(-)0.151**	**(-)1.461**	-	**(-)1.712**	**(-)21.162**	**(-)24.172**	**(-)24.172**
-	-	-	(-)0.005	(-)0.007	(-)0.073	-	(-)0.085	(-)1 028	(-)1.045	(-)1.045
-	-	-	-	-	-	-	-	-	(-)2.338	(-)2.338
-	-	-	-	-	-	-	-	-	-	(-)2.195
2.023	**1.286**	**5.772**	**12.891**	**0.908**	**5.253**	**2.316**	**34.306**	**9.488@**	**8.639**	**83.683**
2.023	**1.286**	**5.772**	**12.891**	**0.908**	**5.253**	**2.316**	**34.306**	-	**8.639**	**83.683**
-	-	-	0 123	0.027	0.152	-	0.302	-	1.539	1.887
-	-	-	1.332	0.776	4.721	-	6.902	-	4.819	46.265
2.023	1.286	-	11 436	0 105	0.38	-	15.23	-	0.229	19.655
-	-	4 838	-	-	-	-	5.584	-	1.117	7.25
-	-	0.934	-	-	-	-	0.958	-	0.935	2.214
-	-	-	-	-	-	2.316	5.33	-	-	6.412

Table I.7

Commercial energy balance for India (1984/85).

(mtoe)

	Primary energy							Sec-
	Coal	**Crude**	**Natural gas**	**Hydro power**	**Nuclear power**	**Soft coke**	**LPG**	**Naphtha**
Supply								
Production	72 269	28.99	6.204	4 54	0 344	.	.	.
Imports	0 328	13 642	.	.	.	.	.	.
Exports	0 059	6 478	.	.	.	.	.	0 658
Stock changes	3 156	0.598	.	.	.	.	(-)0 091	(-)0 287
Availability	**69.382**	**35.556**	**6.204**	**4.54**	**0.344**	**.**	**0.091**	**(-)0.371**
Conversion	**(-)32.498**	**(-)35.556**	**(-)4.159**	**.**	**.**	**0.848**	**0.986**	**3.73**
Soft coke	0 958	.		.	.	0 848	.	
Petroleum refining	.	35 556	.	.	.	.	0 673	3 73
LPG extraction	.	.	0 313	.	.		0 313	
Power generation	31 54	.	1 19	4 54	0 344	.		
Conversion losses	(-)21 027	.	(-)0 845	(-)3 027	(-)0 229			.
Aux cons in power station	(-)1 051	.	(-)0 007	(-)0 007	(-)0 011	.		
T/D losses	.	.	.	.	.	.		
Natural gas flaring etc	.	.	2 656	.	.	.		
Net availibility	**36.884**	**.**	**2.045**	**.**	**.**	**0.848**	1.077	**3.359**
Consumption	**36.884**	**.**	**2.045**	**.**	**.**	**0.848**	1 077	**3.359**
Agriculture	.	.	0 051	.	.		0 085	
Industry	33 175*	.	0 639	.		.		
Transport	3 709	.	. *			.		
Residential	.	.	0 015		.	0 53	0 965	
Other energy uses	.	.	.			0 318	0 027	
Non energy uses	.	.	1 34					3 359

* Includes coking coal use and coal used as feed stock

T D losses not accounted for

ondary energy										
Mogas	**ATF**	**Kero-sene**	**HSD**	**LDO**	**Fuel oils**	**Other Pet pdts**	**Total Pet pdts**	**Thermal power**	**Total power**	**Total energy**
-	-	-	-	-	-	-	-	-	4.884	112.347
-	0.136	2.728	2.663	-	0.172	0.581	6.28	-	-	20.25
-	-	-	0.073	-	0.167	0.077	0.975	-	-	7.512
0.064	0.094	0.016	(-)0 343	(-)0.121	0.06	0 429	(-)0 179	-	-	3.575
(-)0.064	**0.042**	**2.712**	**2.933**	**0.121**	**(-)0.55**	**0.075**	**5.484**	-	-	**121.51**
2.294	**1.381**	**3.515**	**11.092**	**0.878**	**5.423**	**2.325**	**31.624**	**24.924**	**30.834**	**(-)34.997**
-	-	-	-	-	-	-	-	-	-	(-)0.11
2 294	1 381	3 515	11 242	1 119	7 88	2 325	34 159	-	-	(-)1.397
-	-	-	-	-	-	-	-	-	-	-
-	-	-	0 15	0 241	2 457	-	2.848	35.578	40.462	40.462
-	-	-	**(-)0.100**	**(-)0.161**	**(-)1.638**	-	**(-)1.899**	**(-)23.771**	**(-)27.027**	**(-)27.027**
-	-	-	(-)0 005	(-)0 008	(-)0 082	-	(-)0.095	(-)1.153	(-)1.171	(-)1.171
-	-	-	-	-	-	-	-	-	(-)2.636	(-)2.636
-	-	-	-	-	-	-	-	-	-	(-)2.656
2.23	**1.423**	**6.227**	**14.025**	**0.999**	**5.368**	**2.4**	**37.108**	**10.654@**	**9.628**	**86.513**
2.23	**1.423**	**6.227**	**14.025**	**0.999**	**5.368**	**2.4**	**37.108**	-	**9.628**	**86.513**
-	-	-	0 133	0 03	0.148	-	0.311	-	1.769	2.131
-	-	-	1 639	0 87	4.868	-	7 462	-	5.319	46.595
2 23	1 423	-	12 253	0 099	0 352	-	16.357	-	0.243	20.309
-	-	5 219	-	-	-	-	6.184	-	1.309	8.038
-	-	1 008	-	-	-	-	1 035	-	0.988	2.341
-	-	-	-	-	-	2 4	5.759	-		7.099

Table I.8
Commercial energy balance for India (1985/86).
(mtoe)

	Primary energy							Sec-
	Coal	**Crude**	**Natural gas**	**Hydro power**	**Nuclear power**	**Soft coke**	**LPG**	**Naphtha**
Supply								
Production	75.637	30.168	6.969	4.299	0.421	.	.	.
Imports	0 995	15.144	.	.	.	.	.	1 93
Exports	0.103	0.528	.	.	.	.	(-)0 012	0 058
Stock changes	0.284	1.874	.	.	.	.	0 012	(-)0 988
Availability	**76.245**	**42.91**	**6.969**	**4.299**	**0.421**	**0.982**	**1.39**	**5.327**
Conversion	(-)36.367	(-)42.910	(-)4.202	.	.	0.982	.	.
Soft coke	1 087	.	.	.	.	.	0 98	5 327
Petroleum refining	.	42.91	.	.	.	.	0 41	.
LPG extraction	.	.	0 41	.	.	.	.	.
Power generation	35 28	.	0 084	4 299	0 421	.		.
Conversion losses	(-)23 52	.	(-)0.755	(-)2 866	(-) 281	.	.	
Aux cons. in power station	(-)1.176	.	(-)0.008	(-)0 007	(-)0 014	.	.	
T/D losses	.	.	.	.	.	.	.	.
Natural gas flaring etc	.	.	2 728	.	.	.		
Net availability	**39.878**	.	**2.767**	.	.	**0.982**	**1.402**	**3.339**
Consumption	**39.878**	.	**2.767**	.	.	**0.982**	**1.402**	**3.339**
Agriculture	.	.	0 064	.	.	.		
Industry	36.109	.	0 609	.	.	.	0 12	
Transport	3.769	.	.	.	.	.	.	.
Residential	.	.	0 017	.	.	0 602	1 243	.
Other energy uses	.	.	.	.	.	0 36	0 339	
Non energy uses	.	.	2 077	.	.	.		3 339

* Includes coking coal use and coal used as feed stock
@ T/D losses not accounted for

ondary energy										
Mogas	**ATF**	**Kero-sene**	**HSD**	**LDO**	**Fuel oils**	**Other pet pdts**	**Total pet pdts**	**Thermal power**	**Total power**	**Total energy**
-	-	-	-	-	-	-	-	-	4.72	117.494
-	0.16	2.684	0.921	-	0.019	0.227	4.011	-	-	20.15
-	-	-	0.068	-	0.014	0.083	2.095	-	-	2.726
0.033	0.231	0 386	0 582	0.056	0.06	(-)0.059	1 335	-	-	3.493
(-)0.033	**(-)0.071**	**2.298**	**0.271**	**(-)0.056**	**(-)0.055**	**0.203**	**0.581**	**-**	**-**	**131.425**
2.467	**1.618**	**4.211**	**14.97**	**0.954**	**5.54**	**2.35**	**38.827**	**27.363**	**33.408**	**(-)38.028**
-	-	-	-	-	-	-	-	-	-	(-)0.125
2.467	1.618	4 211	15 136	1 218	7.836	2.35	41.143	-	-	(-)1.767
-	-	-	-	-	-	-	-	-	-	0
-	-	-	0.166	0.264	2.296	-	2 726	39.07	43.79	43.79
-	**-**	**-**	**(-).110**	**(-)0.176**	**1.53**	**-**	**(-)1.816**	**(-)26.091**	**(-)29.238**	**(-)29.238**
-	-	-	(-)0.005	(-)0.009	0.076	-	(-)0.09	(-)1.272	(-)1.293	(-)1.293
-	-	-	-	-	-	-	-	-	(-)0.877	(-)2.877
-	-	-	-	-	-	-	-	-	-	(-)2.728
2.434	**1.547**	**6.509**	**15.241**	**0.898**	**5.485**	**2.553**	**39.408**	**11.707[@]**	**10.382**	**93.397**
2.434	**1.547**	**6.509**	**15.241**	**0.898**	**5.485**	**2.553**	**39.408**	**-**	**10.382**	**93.397**
-	-	-	0 154	0 031	0 163	-	0.348	-	1.977	2.389
-	-	-	1.756	0 778	5 033	-	7 687	-	5.654	50.059
-	-	-	13 331	0 089	0.289	-	17.69	-	0.26	21.719
2 434	1 547	-	-	-	-	-	6.698	-	1.456	8.773
-	-	5 455	-	-	-	-	1 093	-	1 035	2.488
-	-	1 054	-	-	-	2 553	5.892	-		7.969

Table I.9

Commercial energy balance for India (1986/87).

(mtoe)

	Primary energy							Sec-
	Coal	Crude	Natural gas	Hydro power	Nuclear power	Soft coke	LPG	Naphtha
Supply								
Production	81 22	30.48	8 443	4 538	0 424			
Imports	1 029	15 476	-	-	-	-		0 036
Exports	0 078	-	-	-	-			2 386
Stock changes	0 382	0 257	-	-	-		( )0 01	0 002
Availability	**81.789**	**45.699**	**8.443**	**4.538**	**0 424**	**-**	**0.01**	**(-)2 352**
Conversion	(-)40.115	(-)45.699	(-)4.608	-	-	**0.881**	**1 682**	**5 845**
Soft Coke	0 995				-	0 881		
Petroleum refining		45 699	-				1 124	5 845
LPG extraction	-	-	0 558	-			0 558	
Power generation	39 12	-	1 667	4 538	0 424			
Conversion losses	(-)26 08	-	(-)1 183	(-)3 025	(-)0 282			
Aux cons. in power station	(-)1 304	-	(-)0 009	(-)0 007	( )0 014			
T/D losses	-	-	-		-			
Natural gas flaring etc	-	-	( )2 383					
Net availability	**41.674**	**-**	**3.835**	**-**	**-**	**0 881**	**1 692**	**3 493**
Consumption	**41.674**	**-**	**3.835**	**-**	**-**	**0 881**	**1 692**	**3 493**
Agriculture		-	0 076		-			
Industry	38 49*	-	0 994		-		0 123	
Transport	3 184	-	-		-			
Residential	-	-	0 02			0 551	1 115	
Other energy uses		-				0 33	0 454	
Non energy uses		-	2 745					3 493

* Includes coking coal use and coal used as feed stock

T D losses not accounted for

ondary energy										
Mogas	**ATF**	**Kero-sene**	**HSD**	**LDO**	**Fuel oils**	**Other pet pdts**	**Total pet pdts**	**Thermal power**	**Total power**	**Total energy**
-	-	-	-	-	-	-	-	-	4.962	125.105
-	0.115	1 985	0.776	-	-	0.245	3.157	-	-	19.662
-	-	-	-	0.083	0.097	0 088	2.654	-	-	2.732
0.011	0 062	0 174	0.198	(-)0 066	(-)0.132	(-)0.03	0.209	-	-	0 848
(-)0.011	**0.053**	**1.811**	**0.578**	**(-)0.017**	**0.035**	**0.187**	**0.294**	-	-	**141.187**
2.691	**1.654**	**5.133**	**15.824**	**0.931**	**5.723**	**2.607**	**42.09**	**(-)30.406**	**(-)36.88**	**(-)40.927**
-	-	-	-	-	-	-	-	-	-	(-)0.114
2 691	1 654	5 133	15 991	1 213	7 891	2 607	44.149	-	-	(-)1 55
-	-	-	-	-	-	-	-	-	-	0
-	-	-	0 167	0 282	2 168	-	2.617	43 404	48.366	48.366
-	-	-	**(-)0.111**	**(-)0.188**	**(-)1.445**	-	**(-)1.744**	**(-)29.007**	**(-)32.314**	**(-)32.314**
-	-	-	(-)0.005	(-)0 009	(-)0 072	-	(-)0 086	(-)1 399	(-)1.42	(-)1 42
-	-	-	-	-	-	-	-	-	(-)3.146	(-)3.146
-	-	-	-	-	-	-	-	-	-	(-)2.383
2.68	**1.707**	**6.944**	**16.402**	**0.914**	**5.758**	**2.794**	**42.384**	**12.998@**	**11.486**	**100.26**
2.68	**1.707**	**6.944**	**16.402**	**0.914**	**5.758**	**2.794**	**42.384**	-	**11.486**	**100.26**
-	-	-	0 16	0 031	0 158	-	0 349	-	2 382	2.807
-	-	-	1 744	0 794	5 243	-	7 904	-	6 035	53.423
-	-	-	14 498	0 089	0 357	-	19 331	-	0.274	22.789
2 68	1 707	-	-	-	-	-	7 335	-	1 626	9.532
-	-	5 82	-		-	-	1 178	-	1 169	2 677
-	-	1 124		-	-	2 794	6.287	-	-	9.032

Table I.10

Commercial energy balance for India (1987/88).

(mtoe)

	Primary energy							Sec-
	Coal	**Crude**	**Natural gas**	**Hydro power**	**Nuclear power**	**Soft coke**	**LPG**	**Naphtha**
Supply								
Production	88.509	30.357	9.825	3.994	0.424	-	-	-
Imports	1.456	17.732	-	-	-	-	-	-
Exports	0.083	-	-	-	-	-	-	2 814
Stock changes	3.681	0.335	-	-	-	-	(-)0 116	(-)0 008
Availability	**86.201**	**47.754**	**9.825**	**3.994**	**0.424**	-	**0.116**	**(-)2.806**
Conversion	(-)47.762	(-)47.754	(-)5.838	-	-	0.73	1.789	5.872
Soft coke	0 825	-	-	-	-	0 73		
Petroleum refining	-	47.754	-	-	-	-	1 159	5 872
LPG extraction	-	-	0.63	-	-	-	0 63	-
Power generation	46.937	-	2.21	3 994	0 424	-	-	
Conversion losses	(-)31.291	-	(-)1 569	(-)2.663	(-)0 263	-	-	
Aux cons. in power station	(-)1.564	-	(-)0 012	(-)0.020	(-)0 014		-	
T/D losses	-	-	-	-	-	-		
Natural gas flaring etc.	-	-	2.998	-	-	-	-	
Net availability	38.439	-	3.987	-	-	0.73	1.905	3.066
Consumption	38.439	-	3.987	-	-	0.73	1 905	3.066
Agriculture	-	-	0 08	-	-	-		
Industry	35 478*	-	1 019	-	-	-	0 208	
Transport	2.961	-	-	-	-	-		
Residential	-	-	0 028	-	-	0 457	1 599	-
Other energy uses	-	-	-	-	-	0 273	0 098	
Non energy uses	-	-	2 86		-			3 066

* Includes coking coal use and coal used as feed stock

@ T/D losses not accounted for

ondary energy										
Mogas	**ATF**	**Kero-sene**	**HSD**	**LDO**	**Fuel oils**	**Other pet pdts**	**Total pet pdts**	**Thermal power**	**Total power**	**Total energy**
-	-	-	-	-	-	-	-	-	4.418	133.109
-	0.041	2.279	1.375	-	-	0.383	4.078	-	-	23.266
-	-	-	0.092	-	0.589	0.103	3.598	-	-	3.681
(-)0.159	0.085	0.056	(-)0.126	0.015	(-)0.27	(-)0.038	(-)0.563	-	-	3.453
(-)0.159	**(-)0.044**	**2.223**	**1.409**	**(-)0.015**	**(-)0.317**	**0.318**	**1.043**	-	-	**149.241**
2.848	**1.805**	**5.333**	**16.65**	**1.043**	**6.078**	**2.648**	**44.066**	**36.351**	**42.98**	**(-)47.654**
-	-	-	-	-	-	-	-	-	-	(-)0.095
2.848	1.805	5.333	16.866	1.303	8.339	2 648	46.173	-	-	(-)1.581
-	-	-	-	-	-	-	-	-	-	0
-	-	-	0.216	0.26	2.261	-	2.737	51.884	56.302	56.302
-	-	-	**(-)0.144**	**(-)0.173**	**(-)1.507**	-	**(-)1.824**	**(-)34.684**	**(-)37.630**	**(-)37.630**
-	-	-	(-)0.007	(-)0.009	(-)0.075	-	(-)0.091	(-)1.667	(-)1.701	(-)1.701
-	-	-	-	-	-	-	-	-	(-)3.649	(-)3.649
-	-	-	-	-	-	-	-	-	-	(-)2.998
3.007	**1.761**	**7.556**	**18.059**	**1.028**	**5.761**	**2.966**	**45.109**	-	**13.322**	**101.587**
3.007	**1.761**	**7.556**	**18.059**	**1.028**	**5.761**	**2.966**	**45.109**	**15.533**[@]	**13.322**	**101.587**
-	-	-	0.183	0.033.	0.163	-	0.379	-	3.171	3.63
-	-	-	1.978	0.891	5.186	-	8.263	-	6.501	51.261
3 007	1.761	-	15.898	0.104	0.412	-	21.182	-	0.333	24.476
-	-	6.333	-	-	-	-	7.932	-	1.958	10.375
-	-	1.223	-	-	-	-	1.321	-	1.359	2.953
-	-	-	-	-	-	2.966	6.032	-	-	8.892

Table 1.11

Commercial energy balance for India (1988/89)

(mtoe)

	Primary energy					Sec-		
	Coal	Crude	Natural gas	Hydro power	Nuclear power	Soft coke	LPG	Naphtha
Supply								
Production	95 373	32 04	11 324	4 868	0 49	.	.	.
Imports	1.455	17 811	.	.	.	.	.	.
Exports	0 147	.	.	.	.	.	.	2 132
Stock changes	1 949	1 048	.	.			(-)0 23	0 067
Availability	94.732	48.803	11.324	4.868	0.49	.	0.23	(-)2.199
Conversion	(-)52.284	(-)48.803	(-)6.927	.	.	1.268	1 986	5 781
Soft coke	1 434	.		.		1 268		
Petroleum refining	.	48 803			.		1 168	5 781
LPG extraction	.	.	0 818	.	.	.	0 818	
Power generation	50 85	.	2 711	4 868	0 49			
Conversion losses	(-)33 9	.	(-)1 924	(-)3 245	(-)0 327			
Aux cons in power station	(-)1 695	.	(-)0 015	(-)0 008	(-)0 016			
T/D losses		.	.					
Natural gas flaring etc			3 398					
Net availability	42.448	.	4.397	.	.	1 268	2 216	3 582
Consumption	42.448	.	4.397	.	.	1 268	2 216	3 582
Agriculture	.	.	0 086					
Industry	39 703*	.	1 152					
Transport	2 745	.	.					
Residential	.	.	0 043			0 793	1 799	
Other energy uses	.					0 475	0 417	
Non energy uses	.		3 116					3 582

* Includes coking coal use and coal used as feed stock

† T/D losses not accounted for

ondary energy										
Mogas	**ATF**	**Kero-sene**	**HSD**	**LDO**	**Fuel oils**	**Other Pet pdts**	**Total Pet pdts**	**Thermal power**	**Total power**	**Total energy**
-	-	-	-	-	-	-	-	-	5.358	144.095
-	0.038	2.87	2.533	-	0.458	0.538	6.437	-	-	25.703
-	-	-	0.103	-	0.009	0.193	2.437	-	-	2.584
(-)0.225	0.095	0.248	0.311	0.07	0.923	(-)0.648	0.611	-	-	3.608
0.225	**(-)0.057**	**2.622**	**2.119**	**(-)0.07**	**(-)0.474**	**0.993**	**3.389**	-	-	**163.606**
3.033	**1.867**	**5.435**	**17.1**	**1.169**	**6.578**	**1.948**	**44.897**	**39.377**	**46.968**	**(-)52.621**
-	-	-	-	-	-	-	-	-	-	(-)0.166
3.033	1.867	5 435	17.239	1.519	8.724	1.948	46.714	-	-	(-)2.089
-	-	-	-	-	-	-	0.818	-	-	0
-	-	-	0.139	0.35	2.146	-	2.635	56.196	61.554	61.554
-	-	-	**(-)0.093**	**(-)0.233**	**(-)1.431**	-	**(-)1.757**	**(-)37.581**	**(-)41.153**	**(-)41.153**
-	-	-	(-)0.004	(-)0.011	(-)0.071	-	(-)0.086	(-)1.796	(-)1.820	(-)1.820
-	-	-	-	-	-	-	-	-	(-)3.995	(-)3.995
-	-	-	-	-	-	-	-	-	-	(-)3.398
3.258	**1.81**	**8.057**	**19.219**	**1.099**	**6.104**	**2.941**	**48.286**	**16.819@**	**14.586**	**110.985**
3.258	**1.81**	**8.057**	**19.219**	**1.099**	**6.104**	**2.941**	**48.286**	-	**14.586**	**110.985**
-	-	-	0.091	0.033	0.18	-	0.304	-	3.471	3.861
-	-	-	1 794	0 97	5.477	-	8 241	-	7.118	56.214
3 258	1 81	-	17 334	0 096	0 447	-	22.945	-	0.365	26.055
-	-	6 753	-	-	-	-	8.552	-	2.144	11.532
-	-	1.304	-	-	-	-	1.721	-	1.488	3.684
-	-	-	-	-	-	2 941	6.523	-	-	9.639

Table I.12

Commercial energy balance for India (1989/90)

(mtoe)

	Primary energy							Sec-
	Coal	**Crude**	**Natural gas**	**Hydro power**	**Nuclear power**	**Soft coke**	**LPG**	**Naphtha**
Supply								
Production	98.475	34 087	14 557	5 232	0 39	.		
Imports	2 161	19 49	.	.	.			
Exports	0 078	.	.	.	.			2 078
Stock changes	2 7	1 635	.	.		.	( )0 363	( )0 06
Availability	**97.858**	**51.942**	.	**5.232**	**0.39**	.	**0.363**	**(-)2.018**
Conversion	(-)52.397		(-)9.173	.	.	**0.564**	**2 2**	**5 619**
Soft coke	0 637					0 564		
Petroleum refining		51 942	.				1 332	5 619
LPG extraction	.	.	0 988	.	.		[illegible]	
Power generation	51 76	.	3 321	5 232	0 39			
Conversion losses	(-)34 507	.		(-)3 488	(-)0 26			
Aux cons in power station	( )1 725	.	(-)0 019	( )0 008	(-)0 013			
T-D losses	.							
Natural gas flaring etc		.	4 984					
Net availability	45.461	.	5.384	.	.	**0 564**	**2 563**	**3 601**
Consumption	45.44	.	5.384'	.	.	**0 564**	**2 563**	**3 601**
Agriculture	.	.	0 105					
Industry	43 214'		1 41	.				
Transport	2 247							
Residential	.		0 053			0 353	2 243	
Other energy uses	.					0 211	[illegible]	
Non energy uses		.	3 816					3 601

' Includes coking coal use and coal used as feed stock

T-D losses not accounted for

' Based on last year's percentage share of various end uses

ondary energy										
Mogas	**ATF**	**Kero-sene**	**HSD**	**LDO**	**Fuel oils**	**Other Pet pdts**	**Total Pet pdts**	**Thermal power**	**Total power**	**Total energy**
-	-	-	-	-	-	-	-	-	5.622	152.741
-	0.285	2.713	3.155	-	-	0.606	6.759	-	-	28.41
-	-	-	-	-	0.212	0.428	2.718	-	-	2.796
(-)0.174	0.072	0.059	0.083	0.056	(-)0.081	(-)0.309	(-)0.717	-	-	3.618
0.174	**0.213**	**2.654**	**3.072**	**(-)0.056**	**(-)0.131**	**0.487**	**4.758**	-	-	**174.737**
3.561	**1.677**	**5.956**	**18.23**	**1.258**	**6.569**	**3.314**	**48.384**	**40.507**	**48.678**	**(-)55.447**
										(-)0.073
3.561	1.677	5 956	18.358	1 594	3.818	3 314	50.229	-	-	(-)1.713
-	-	-	-	-	-	-	0.868	-	-	0
-	-	-	0.128	0.336	2.249	-	2.713	57.794	63.416	63.416
-	-	-	**(-)0.085**	**(-)0.224**	**(-)1.499**	-	**(-)1.808**	**(-)38.673**	**(-)42.421**	**(-)42.421**
-	-	-	(-)0.004	(-)0.011	(-)0.075	-	(-)0.09	(-)1.834	(-)1.855	(-)1.855
-	-	-	-	-	-	-	-	-	(-)4.401	(-)4.401
-	-	-	-	-	-	-	-	-	-	(-)4.984
3.735	**1.89**	**8.61**	**21.302**	**1.202**	**6.438**	**3.801**	**53.142**	**17.287**	**14.739**	**119.29**
3.735	**1.89**	**8.61**	**21.302**	**1.202**	**6.438**	**3.801**	**53.142**	-	**14.739**	**119.29**
-	-	-	0.214	0.037	0.188	-	0.439	-	3.68	4.224
-	-	-	2 1	1.077	5.875	-	9.052	-	6.819	60.495
3.735	1.89	-	18.988	0.088	0.375	-	25.076	-	0.35	27.673
-	-	7.216	-	-	-	-	9.459	-	2 375	12.24
-	-	1.394	-	-	-	-	1.714	-	1.515	3.44
-	-	-	-	-	-	3.801	7.402	-		11.218

Conversion factors for various energy fuels to mtoe are as follows:

Coal	1 mt = 0.49 mtoe
Natural gas	1 million cu.m. = 856.8 toe
Hydro power	12000 GWh = 1 mtoe
Nuclear power	12000 GWh = 1 mtoe
LPG	1 mt = 1.059 mtoe
Naphtha	1 mt = 1.029 mtoe
Mogas	1 mt = 1.029 mote
ATF	1 mt = 1.020 mtoe
Kerosene	1 mt = 1.010 mtoe
HSD	1 mt = 1 mtoe
LDO	1 mt = 1 mtoe
Fuel oils	1 mt = 0.956 mtoe
Other pet pdts	1 mt = 1 mtoe

1 mtoe = 10.2 x 10^{12} kCals

Energy supply

Coal and lignite

Reserves

Coal is the most abundant commercial energy source in India. Coal resources are assessed on a continuous basis, by the Geological Survey of India, through regional mapping and exploratory drilling. Detailed drilling is done by the Mineral Exploration Corporation, Central Mine Planning and Design Institute, to establish proven reserves.

Indian coals are largely of bituminous grade, and an estimated 99.5% of indigenous coal resources are in the Gondwana Basins. A total of about 159 billion tonnes of resources occur up to a depth of about 1200 metres. Of these, about 70% occur in seams of thickness 0.5 metres or more. About 59 billion tonnes of the estimated reserves are actually proven.

Coking and blendable coals amount to less than 16% of the total resources. Coking and superior quality coals are found mostly in the eastern region, mainly in the Jharia and Raniganj coalfields; while the inferior quality coals have a wider distribution. Indian coals usually have a high ash content, except in case of coal seams which are interbanded. The sulphur content however, is very low.

Lignite deposits occur mostly at Neyveli (Tamil Nadu), where about 4.4 billion tonnes of reserves are in the inferred category. These account for about 75% of total lignite reserves in the country. Of these, about 2.1 billion tonnes fall in the proven category.

Table II.1.1
Category wise resources of coal (mt).
(as on January 1991)

Type of coal	Proved	Indicated	Inferred	Total
Coking	14108	13019	2032	29159
Non coking	44875	71003	47332	163200
Total	**58983**	**84022**	**49354**	**192359**

Source: Ministry of Energy, Department of Coal, Annual Report, 1990-91, GOI.

Table II.1.2
Coal resources (as on January 1, 1991).

State	Reserves (mt)	
	Proved	Total
Andhra Pradesh	5278	10771
Arunachal Pradesh	31	90
Assam	133	295
Bihar	27787	62085
Madhya Pradesh	8567	37053
Maharashtra	2891	6071
Meghalaya	89	460
Nagaland	4	20
Orissa	4827	44305
Uttar Pradesh	662	1062
West Bengal	8714	30147
Total	**58983**	**192359**

Source: Ministry of Energy, Department of Coal, Annual Report 1990-91, GOI.

Table II.1.3
Lignite reserves.
(mt)

State	Proved	Inferred
Tamil Nadu	2100	4450
Pondicherry	-	480
Rajasthan	615	838
Gujarat	220	363
Jammu & Kashmir	7	90

Source: Ministry of Energy, 'A Profile, NLC Ltd.'

Production

Following a period of stagnation in the latter half of the 1970s, coal production increased rapidly after 1979/80. From about 104 mt in 1979/80, it rose to about 212 mt in 1990/91. Coal India Limited (CIL), the premier coal producer in the country, contributed over 89% of the total production in 1990/91.

An integrated development programme for the coal industry was initiated after its nationalization in 1973. Reorganization/reconstruction of existing mines was a major activity initiated during the 1970s, along with a programme for optimal selection of new technologies, standardization of equipment, and infrastructure development. New mining techniques were also introduced, as opencast mining increased.

Larger and more powerful equipment (shovels, draglines, dumpers etc.) are now being deployed to permit opencast mining up to a depth of as much as 500 metres. Opencast mining is being utilised effectively to extract coal from those areas where coal reserve is locked in pillars under shallow cover. It is also being used effectively to work out areas with fires which were either difficult to work by underground methods or these methods would have implied large losses of coal owing to safety barriers. In the underground mines, which are being planned for exploiting deeper deposits, the approach now is towards a shift from the semi-mechanized bord and pillar method (which results in high mining losses and low productivity, with a high cost of

production) to mechanized bord and pillar operations, and progressive expansion to longwall methods of mining.

With these measures, the output per man-shift (OMS) has risen to 1.31 tonnes in 1990/91 and is further anticipated to rise to 2 tonnes by 1999/2000. For opencast mines alone, the OMS is expected to reach the 4 tonne mark by the turn of the century. Although these targets for OMS are considerably higher than the present levels, they are still short of what some of the other major coal producing countries have achieved -- a part of this difference however, may arise from the fact that only manpower that is employed directly for coal mining operations is considered for computing the OMS in other countries, while in India, indirect employment is also considered.

Coal stocks at pit-heads usually decline during the months April to October every year, when coal production is low (due to various reasons, including monsoon rains, power shortages, absenteeism of workers etc.). However, there is a distinct trend towards rising pit-head stocks since 1979/80. This may reflect the fact that transportation bottlenecks continue to exist -- despite the fact that the railways have increased coal haulage considerably since 1980.

The lignite reserves at Neyveli are exploited by the Neyveli Lignite Corporation (NLC). NLC operates two mines, one of a capacity of 6.5 million tonnes per annum (mtpa), and the other of 4.7 mtpa. The second mine is now being expanded to a 10.5 mtpa capacity.

Table II.1.4
Lignite statistics.
(mt)

	1981/82	1983/84	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Production (total)	**6.306**	**7.297**	**8.04**	**9.60**	**11.16**	**12.40**	**12.80**	**11.76**
Tamil Nadu	5.876	6.679	7.24	8.52	10.15	11.40	11.23	11.76
Gujarat	0.430	0.618	0.80	1.08	1.01	1.00	1.57	N.A.
Despatches	**6.295**	**7.241**	**7.675**	**8.03**	**8.10**	**8.54**	**10.16**	**N.A.**
Tamil Nadu	5.865	6.623	6.869	7.12	7.09	7.67	9.31	N.A.
Gujarat	0.430	0.618	0.806	0.91	1.01	0.87	0.85	N.A.
Stocks at end of year (total)	**0.120**	**0.079**	**0.216**	**0.37**	**0.41**	**0.37**	**0.18**	N.A.
Tamil Nadu	0.120	0.079	0.216	0.37	0.41	0.37	0.18	N.A.
Gujarat								

Sources: [1] Coal Controllers' Organization, All India Annual Coal Statistics, various issues, GOI, Calcutta; [2] Coal Controllers' Organization, Monthly Coal Statistics, March 1986, GOI, Calcutta.

Table II.1.5

Production, despatches and closing stock of coal -- all India (million tonnes).

	1975/76	1981/82	1983/84	1985/86	1987/88	1988/89	1989/90	1990/91
Production (total)	**99.68**	**124.23**	**138.24**	**14.24**	**179.75**	**194.60**	**200.85**	**211.73**
Coking	22.19	30.25	35.98	35.65	41.08	42.72	44.43	45.36
Non-coking	77.49	93.98	102.26	118.59	138.67	151.88	156.46	166.37
Despatches (total)	**91.96**	**118.10**	**130.27**	**151.04**	**170.5**	**183.7**	**191.93**	**200.39**
Coking	21.16	24.54	34.85	34.34	38.61	41.2	41.04	41.93
Non-coking	70.80	93.56	95.42	116.50	131.89	142 5	150 89	158.46
From CIL* (total)	77.96	103.34	114.66	134.11	150.12	161.37	170 10	179 09
by rail	59.81	69.78	N.A.	N.A.	N.A.	92.19	96 58	100.95
by road	13.38	26.61	N.A.	N.A.	N.A.	26 74	24 16	25 86
by other means	4.77	6.95	N.A.	N.A.	N.A.	42.44	49.3€	52 28
From other coal companies**	14.00	14.76	15.61	N.A.	20.37	18 34		
Closing stocks at the end of Year (total)	**11.84**	**21.25**	**23.42**	**27.78**	**33.74**	**37.30**	**37.42**	**42.88**
Coking	1.67	9.07	7.67	9.31	12.40	12.24	11 64	15 30
Non-coking	10.17	12.18	15.75	18.47	21.34	25.06	25 78	27 58

* Coal India Ltd. (CIL), includes Eastern Coalfields Ltd. (ECL), Bharat Coking Coal Ltd.(BCCL), Central Coalfields Ltd. (CCL), Western Coalfields Ltd. (WCL) and North-Eastern Coalfields Ltd (NECL)

** Includes Singareni Collieries Company Ltd. (SCCL), Tata Iron and Steel Company Ltd.(TISCO), Damodar Valley Corporation (DVC) and coalfields in Jammu and Kashmir.

Sources: [1] Coal Controllers' Organization, All India Annual Coal Statistics, various issues, GOI, Calcutta, and [2] Centre for Monitoring Indian Economy (CMIE), Current Energy Scene in India, Bombay, July 1989

Table II.1.6
Share of open cast coal production.

	Total production (mt)	Production from open cast mines (mt)	Share of prod. from OC mines (%)
1960/61	55.67	10.86	19.5
1970/71	72.95	14.68	20.1
1980/81	114.00	41.15	36.1
1982/83	130.60	55.76	42.7
1984/85	147.40	74.00	50.2
1985/86	154.30	77.90	50.4
1986/87	165.78	111.89	67.5
1987/88	179.85	105.74	58.8
1988/89	194.38	116.29	59.8
1989/90*	178.62	119.88	67.1
1990/01*	189.64	133.53	70.4

* For CIL only.

Sources: [1] R.G. Mahendru, Indian Energy Perspective - Coal, Presented at the 12th Congress of the World Energy Conference, New Delhi, September 1983;
[2] Ministry of Energy, Department of Coal, GOI, New Delhi; and
[3] CMIE, Current Energy Scene in India, Bombay, July 1990.

Table II.1.7

Trends in coal mining.

	Operating (as in 1983)	Planned
Open cast mining		
Coal production (mt/year)		=< 3
Overburden (million cu.m./year)		=< 6
Average stripping ratio (cu.m./t)	=< 2	3-7
Depth (metres)	100-120	Upto 430
OMS (tonnes)	1.8	Upto 10
Electric power cons (kWh/tonne)	3-4	8-10
Size of rope shovels (cu.m.)	Upto 10	
Size of hydraulic shovels(cu.m.)	0.9-3	4-10
Size of rear dumpers (tonnes)	25,35,50	85,120,170
Size of coal haulers (tonnes)	=< 50	100,120
Size of draglines (cu.m.)	4-34	24-32
Size of drills (mm)	=<250	311
Underground mining		
Size of mine (mt/year)	0.5-0.8	2-3.5
Depth (metres)	100-400	250-700
OMS (tonnes)	0.55	2-3
Electric power cons.(kWh/t)	10-15	25-30
Face of operating voltage (volts)	550	1100

Source: R.G. Mahendru Indian Energy Coal, Presented at the World Energy Conference, New Delhi, September 1983

Table II.1.8

Trends in output per manshift (OMS, tonnes).

	Overall			Opencast		Underground	
	All	CIL	SCCL	CIL	SCCL	CIL	SCCL
1985/86		0.92	0.81	2.24	5.40	0.98	0.70
1986/87	1.00	0.99	0.80	2.44	5.08	0.54	0.66
1987/88	1.07	1.08	0.95	2.65	4.68	0.54	0.78
1988/89	1.13	1.17	0.96	2.91	5.18	0.57	0.76
1989/90		1.21	0.99	3.06	5.46	0.55	0.71
1990/91		1.31	0.99	3.34	4.76	0.54	0.65

Note: The manshift considered for calculating OMS includes work by all personnel engaged in mining operations, administrative/managerial and other services of the coal companies, as well as by manpower engaged in social activities (such as schools, water supply, post and telegraph etc.) in mining townships. The stagnancy in UG manpower productivity is mainly due to excess manpower in the unskilled category, transfer of which for better utilisation has often been confronted with industrial relations' problems. Other causes are ,exhaustion of old mines, delay in project execution etc., thus resulting in decline of UG production.
Source: Annual Report 1990/91, Deptt of Coal, GOI.

Quality of Indian coals

The basic property of coal as a fuel, is its heat potential, or its calorific content. Other physical and chemical characteristics, particularly ash and moisture content are also important properties. Sulphur content of Indian coals is usually low.

Indian coals have a high ash content. Ash comprises residual non-combustible matter that comes from silt, clay, silica etc., which may have contaminated coal at the time of deposition and formation. The heating value of coal reduces with increase in ash, because some heat is required to melt it -- this may be a significant fraction of the total gross calorific value (GCV) of coal if the ash content is high. It is for this reason that a useful heating value (UHV) is specified for Indian coals, in place of GCV. The difference between GCV and UHV increases with an increase in ash content.

The following formula is a convenient way to estimate UHV if the ash and moisture contents are known :

UHV (kcal/kg) = 8900 - 138 (% Ash + % Moisture)

The moisture content of non-coking coals is also usually high (ie, >= 2%).Coking coals however, have moisture content of less than 2%.

The grading of coking coals is basically related to the percentage ash content; while that of non-coking coals is based on UHV. This difference in the grading criteria arises largely because the moisture content of coking coals is low.

Over the past decade or so, the average calorific content of both coking and non-coking coals has declined. This may be due to an increase in production from mechanized open-cast mines, which leads to significant proportions of free dirt, boulders, and other lumpy, extraneous matter along with coal. Even from 1987/88 to 1990/91, the share of Steel Grades I and II coking coals in total coking coals mined by CIL, has reduced from about 2% to 0.9%. Similarly, the share of Grade A,B non-coking coals to total non-coking coal mined by CIL, has also declined from 21.9% to 17.2% during the same five year period.

Table II.1.9
Grading of coking coals.

Prime and medium coking coals	
Grade	**Ash content %**
Steel grade I (S-I)	=< 15
Steel grade I (S-II)	15-19
Washery grade I (W-I)	19-21
Wahsery grade II (W-II)	21-24
Washery grade III (W-III)	24-28
Washery grade IV (W-IV)	28-35
Semi-coking and weakly coking coals	**Ash plus moisture**
Grade	**Content %**
Semi-coking I (SC-I)	=< 19
Semi-coking II (SC-II)	19-24

Table II.1.10
Grading of non-coking coals.

Grade	Ash + moisture content (%)	Useful heating value (kcal/kg)	Median gross calorific value (kcal/kg)
A	=< 17	> 6200	6300
B	17-19	5600-6200	6100
C	19-24	4940-5600	5700
D	24-32	4200-4940	5200
E	32-35	3360-4200	4700
F	> 35	2400-3360	4000
G	> 35	1300-2400	3300

Table II.1.11

Relationship between Gross Calorific Value (GCV) and Useful Heat Value (UHV).

Ash content (%)	GCV-UHV (kCal/kg)
2	20
4	50
6	80
8	105
10	145
12	200
14	240
16	300
18	380
20	480
22	600
24	720
26	860
28	960
30	1030
32	1090
34	1165
36	1240
38	1300
40	1370
42	1440
44	1500
46	1575
48	1650
50	1710

Table II.1.12

Grade-wise production of coal (mt).

Grade	1985/86 CIL	1987/88 CIL	1988/89	1989 90	1990/91
Coking coal					
S I	0 025	0 013	0 03	0 029	0 027
S II	1.317	0 791	0 57	0 493	0 341
W I	2 407	2.823	3.22	2.301	1 424
W II	13.783	14 218	6 04	3 790	1 572
W III	3.966	4.863	13 52	12 280	12 952
W IV	8.010	11 429	17 81	20 280	22 750
S/C I	0.343	0.731	0.71	0 604	0 053
S/C II	0.180	0.190	0.19	0 160	.
Sub-total*	30.571	36.797	42.05	39 723	39 119
Non-coking coals					
A	4 057	3.885	2.94	3 913	3 638
B	21.276	22 891	23 13	21 880	21 973
C	25 173	29 194	35 13	34 010	40 118'
D	17 206	20 176	27 18	20 710	23 219'
E	14 256	31 041	38 95	25 030	31 792'
F	20 320	14 876	23 15	32 990	42 969'
G	0.340	.	0 09		
N S.coke	0 169		0 06		
N G	.	0 188	1 07	0 070	2 595'
Sub-total	102 797	122 251	152 33	138 613	148 695
Total	**133.368**	**159.048**	**194.38**	**178.59***	**189.65**

* The sub total includes SLV and non-graded coal

' CIL only

CIL and SCCL

Sources [1] Coal Controllers' Organization, All India Annual Coal Statistics, various issues, GOI, Calcutta, and

[2] Annual Report 1990/91, Deptt of Coal, GOI

Coal washing

Owing to the generally poor and deteriorating quality of Indian coals, the beneficiation processes become important.

Washed coals are not only relatively easier to use, they are also easier to transport, and may not pose as many problems for the nation's already overburdened transportation infrastructure. However, washeries for coking coals only have been established so far; although there are plans to establish washeries for certain grades of non-coking coals also.

At present, the CIL operates 15 washeries. Data for the production of washed coal and middlings during 1990/91, are available for these washeries. There are other washeries also, operated by TISCO, IISCO and SAIL, for all of which up-to-date information is not readily available.

Table II.1.13

Washery statistics.

	Coking coal supply ('000 tonnes)		[redacted] duction ('000 tonnes)				
			Washed coal		***Middlings***		**Rated capacity (tonnes/hr)**
	1989/90	1990/91	1989/90	1990/91	1989/90	1990/91	
Coal India Ltd	15450	15186	8248	8375	4546	4259	4765
Bharat Coking Coal Ltd.	7402	6775	3890	3688	2237	1771	2670
Barora	218	132	75	46	91	56	N.A.
Bhojudih	1592	1573	1025	1048	31	24	500
Dugda I	1172	1138	534	554	402	306	600
Dugda II	1171	1153	564	583	537	455	500
Lodna	267	269	170	170	48	51	70
Moonidih	843	754	421	369	292	176	N.A.
Patherdih	1005	771	516	413	482	286	300
Sudamdih	1046	908	523	452	329	392	700
Mahuda	88	77	62	53	25	25	N A
Central Coal-fields Ltd.	7539	7816	4039	4314	2162	2300	2095
Gidi	1426	1435	732	768	549	532	500
Kargali	2092	2249	1144	1225	565	550	680
Kathara	1695	1573	751	698	390	398	715
Sawang	1086	964	704	641	306	297	200
Rajrappa	1240	1595	708	982	352	523	N A
Western Coal fields Ltd.	509	595	319	373	147	188	N.A.
Nandan	509	595	319	373	147	188	N A
Tata Iron & Steel Co.Ltd.	3800	N.A.	2030	1940	1099	N.A.	985
Jama Doba	1440	N A	974	930	215	N A	985
W. Bokaro I	570	N A	342	|	174	N A	600
W Bokaro II	1790	N A	714	| 1010	710	N A	N A
Indian Iron & Steel Co. Ltd.	1000	N.A.	426	480	120	N.A.	550
Chasnala	1000	N A	426	480	120	N A	550
Steel Authority of India Ltd.	550	N.A.	415	390	N.A.	N.A.	720
Durgapur (HSL)	550	N A	415	390	N A	N A	720

Sources: [1] Coal Controller's Organisation, Coal Directory of India

[2] CIL, Annual Report

Table II.1.14

Consumerwise offtake* of coal.
(mt)

Consumer	**1988/89**	**1989/90**	**1990/91**
Power houses	102.01	113.00	116.72
Steel plants & cokeries	28.58	28.37	30.05
Loco	6.35	5.73	5.17
Cement plants	9.55	8.74	9.74
Fertilizer plants	4.09	3.97	3.90
Soft coke manufacturing	1.74	1.30	1.27
Export	0.19	0.16	0.09
Brick kilns, textile chemical, paper & other industries	35.10	34.55	39.12
Colliery cons.	4.02	3.97	4.01
Total offtake	**191.63**	**199.79**	**210.07**

* Excluding supply of washery middlings

Source: Annual Report 1990/91, Deptt of Coal, GOI.

Hydrocarbons

Reserves and exploration

The total area of sedimentary basins in India is about 1.72 million sq.km, of which, 1.4 million sq.km are on land, and the remaining offshore, within the 200 metres isobath line. Of the 26 sedimentary basins, 13 are of interest geologically. According to one estimate, the prognosticated reserves in these (Category I, II and III) basins are about 20 billion tonnes of oil and oil equivalent of gas.

Compared to the rather large prognostications, the reserves in the proven and (balance) recoverable category are rather small. In fact, as of January 1987, only about 3.3 billion tonnes of in-place oil and gas reserves had been established. And as of January 1990, only 757 mt of crude oil and 686 billion cubic metres (bcm) of natural gas reserves were in the proven and recoverable category[1]. Only a portion of these reserves may actually be recovered. This clearly highlights the scope for expanding exploratory activity.

The Oil and Natural Gas Commission (ONGC) and Oil India Ltd. (OIL) have expanded their exploratory activity rapidly, particularly since 1981/82. This is evident both from the exploratory meterage drilled, and the number of exploratory wells drilled. In fact, the increase has been more rapid in the offshore areas, and perhaps represents a rationalization of exploratory activity in line with reserve prognostications.

Although a detailed break-up of exploratory drilling basin-wise is not readily available, it is understood that about 76% of the exploratory meterage drilled during the Sixth Five Year Plan (FYP) period (1980/81-1984/85) was in Category I basins. The bias towards exploration in Category I basins was more evident during the 1960s and 1970s. A rationalization of exploration activity across various categories of basins is considered beneficial because additional reserves in Category I basins are likely to be in subtle structural and stratigraphic traps with only small accumulation in most cases, while geophysical surveys indicate that Category II and III basins have several large structures that are favourable for hydrocarbon accumulation.

However, exploratory drilling by both ONGC and OIL has consistently been short of targets. The set targets were not met, partly because of delays in supply of

[1]The total amounts to about 1375 mtoe of oil and oil equivalent of gas (1 bcm of gas is approximately equivalent to 0.865 mtoe).

indigenous rigs from BHEL, and delays in finalizing orders for mobile and charter hire rigs. Adverse climatic conditions also affected the performance. Similar delays were also experienced for seismic surveys.

Table II.2.1

Prognosticated hydrocarbon resources*.

a. Total (billion tonnes)	20.545
b1 In Offshore areas (%)	62.2
b2 In onshore areas (%)	37.8
c1 In Category I basins (%)	55
c2 In Category II basins (%)	27
c3 In Cateogory III basins (%)	18

* Excluding Category IV basins. Category IV basins are those, which on the analogy with similar hydrocarbon bearing basins in the world, may be considered prospective (e.g Gondwana Basin, Vindhyan Basin, Deccan Synecline).

a Figure refers to billion tonnes of oil plus oil equivalent natural gas.

c1 Proved Petroliferous basins with commercial production (e.g. Bombay High Offshore Basin, Cambay Basin and Upper Assam).

c2 Sedimentary Basins with known occurance of hydrocarbons, but from which, no commercial production has yet been obtained (e.g. Basins in the Assam - Arakan Fold Belt, Bengal, Andaman and Nicobar, Krishna-Godavari, Cauveri, Western Rajasthan and Himalayan Foothills).

c3 Sedimentary Basins in which significant shows of hydrocarbons have not yet been found, but which, on general geological grounds, are considered to be prospective. (e.g. Basins in Kerala-Konkan, Saurashtra and Kutch).

Source: Government of India, Department of Petroleum, New Delhi, 1991.

Table II.2.2

Proven and balance recoverable reserves of crude oil (million tonnes).

Year	On-Shore		Off-Shore	Total
	Gujarat	Assam	Bombay High	
1970	56.38	71.46	-	127.84
1971	51.08	62.70	-	113.78
1972	52.28	72.90	-	125.18
1973	49.45	77.87	-	127.32
1974	48.45	76.05	-	124.50
1975	45.72	84.41	13.77	143.90
1976	45.79	81.99	147.68	275.46
1977	45.62	82.28	175.28	303.18
1978	47.49	78.50	221.04	347.03
1979	45.34	82.81*	226.29	354.44
1980	52.73	82.65*	230.95	366.33
1981	51.48	89.00*	328.29	468.77
1982	53.18	91.52*	325.18	469.88
1983	90.58	97.03*	338.70	526.31
1984	88.0	99.01*	323.81	510.82
1985	86.61	101.80*	311.10	499.51
1986	98.64	113.83*	345.54	558.01
1987	132.05	119.03*	330.35	581.43
1988	143.02	124.38*	371.04	638.44
1989	155.12	140.24*	430.86	726.72
1990	161.71	144.95*	450.74	757.40

* Includes crude oil reserves in Nagaland.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.3

Proven and balance recoverable reserves of natural gas (billion cubic metres).

Year	On Shore			Off Shore	Total
	Gujarat	Assam	Rajasthan	Bombay High	
1970	19.66	42.82	-	-	62.48
1971	18.84	43.45	-	-	62.29
1972	16.88	45.25	0.38	-	62.51
1973	16.35	49.71	0.38	-	66.44
1974	16.18	51.30	0.38	-	67.86
1975	15.72	65.24	0.43	6.28	87.67
1976	16.41	61.42	0.43	106.62	184.88
1977	16.20	63.76	0.43	148.08	228.47
1978	15.66	63.62	0.43	186.15	265.86
1979	15.80	63.35*	0.43	264.64	344.22
1980	16.39	63.53*	0.43	270.96	351.91
1981	15.99	65.19*	0.43	329.04	410.65
1982	18.18	70.66*	0.43	330.62	419.83
1983	18.95	78.67*	0.43	377.21	475.26
1984	18.60	81.31*	0.54	377.80	478.25
1985	21.87	87.67*	0.54	368.55	478.63
1986	26.99	91.83*	0.54	377.69	497.05
1987	41.26	97.82*	0.74	400.99	540.81
1988	62.11	105.49*	0.78	411.09	579.47
1989	85.59	120.49*	1.00	447.47	647.55
1990	92.58	135.47*	1.04	457.36	686.45

* Includes Natural Gas Reserves in Tripura and Nagaland.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.4

Oil and gas discoveries during 1990-91.

Basin	Prospect/Structure	Nature of find
Krishna Godavari	Mori	Oil
	Elamanchilli	Gas
	Manepalli	Gas
Rajasthan	Kharotar	Gas
	Bhakri Tibber (BT-5)	Gas
	Bankia	Gas
Bombay offshore	WO-3	Gas
	B-149	Gas
	B-163	Gas
	B-183	Gas
K.G. offshore	GS-38-1	Gas

Source: Centre for Monitoring Indian Economy, Current Energy Scene in India, October 1991

Table II.2.5

Exploratory drilling done by ONGC and OIL.

Year	Onshore		Offshore		Total	
	Meterage drilled (km)	No. of wells	Meterage drilled (km)	No. of wells	Meterage drilled (km)	No. of wells
1970/71	106	51+1[P]	1	-	107	52+1[P]
1975/76	120	49+1[P]	19	10	139	59+1[P]
1976/77	116	49+1[P]	35	17	151	66+1[P]
1977/78	113	47+2[P]	39	20	152	67+2[P]
1978/79	96	38+1[P]	43	16	139	54+1[P]
1979/80	98	43+2[P]	40	15+1[P]	138	58+3[P]
1980/81	96	44+1[P]	40	15+1[P]	136	59+2[P]
1981/82	130	52+2[P]	39	12	169	64+2[P]
1982/83	128	57+3[P]	57	17	185	74+3[P]
1983/84	157	61+3[P]	70	22+1[P]	227	83+4[P]
1984/85	186	70+5[P]	62	20+1[P]	248	90+6[P]
1985/86	237	91	100	34	337	125
1986/87	236	78+3[P]	132	44+3[P]	368	122+6[P]
1987/88	307	104+4[P]	111	39+3[P]	418	143+7[P]
1988/89	362	122	167	73	618	249
1989/90	508	204	169	61	668	265
1990/91*	434	176	184	73	618	249

* Provisional.

[P] Partly Drilled.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.6

Achievements of exploratory drilling ('000 metres).

	1987/88			1988/89			1989/90		
	ONGC	OIL	Total	ONGC	OIL	Total	ONGC	OIL	Total
Onshore	577	118	695	707	128	835	971	130	1101
Offshore	266	6	272	282	-	282	353	-	353

Source: [1] Centre for Monitoring Indian Economy, Current Energy Scene in India, October 1991; [2] Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.7

Targets for exploratory and development drilling (onshore + offshore).

Year	ONGC	OIL	Total
1988-89	1031.71	166.5	1198.25
1989-90	1587.1	142.05	1729.15
1990-91	1217.97	168.00	1385.97

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.8
Progress of seismic surveys (%).

State	Up to 1979/80	1980/81 to 1986/87	1987/88	Up to 1987/88		
				Total	Reflection	Refrection
a. Onshore (line km)	**122840**	**115941**	**50935**	**289716**	**145990**	**143726**
a1 Andhra Pradesh	14.0	23.7	26.3	26.3	20.0	25.5
a2 Assam	14.4	14.9	14.9	21.4	15.8	14.4
a3 Gujarat	36.1	25.6	25.6	33.6	31.5	28.7
a4 Other States	35.5	35.8	35.8	18.7	32.7	31.4
b. Offshore (line km)	**134250**	**147967**	**33899**	**316116**	**302273**	**13843**
c. Total (line km)	**257090**	**263908**	**84834**	**605832**	**448263**	**157569**

a1 Includes Tamil Nadu.
a2 Includes Tripura, Mizoram, Arunachal Pradesh and Meghalaya.
a3 Includes Kutch, Maharashtra and Madhya Pradesh for 1979-80.
a4 Includes Bihar, Himachal Pradesh, Punjab, Jammu and Kashmir, Orissa, Uttar Pradesh, Rajasthan and West Bengal.
Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Production

Along with exploratory drilling, developmental drilling has also increased substantially in the 1980s. Until 1985/86 at least, this led to a rapid rise in indigenous crude oil and natural gas production. From about 8.5 mt of crude oil and 2.4 bcm of gross natural gas production in 1975/76, the production levels increased to over 32 MMT and 13.2 bcm of oil and gas respectively in 1988/89. This increase was due largely to accelerated production from the Bombay High Offshore Basin. In 1988/89, oil produced from Bombay High accounted for 66% of total crude oil production in the country; and gross production of its associated and free gas reserves also accounted for about 74%. After 1988/89 however, the indigenous production of crude oil has remained at about the 33 mt mark, while gross natural gas production has continued to rise -- to nearly 18 bcm in 1990/91.

Although gross natural gas production was about 18 bcm in 1990/91, net production was less than 12.8 bcm. Over 30% of gas produced was flared away. As a percentage of gross production, net production has increased during the past decade, but it has not been possible to eliminate flaring. This is due to several reasons. Delays in

commissioning down-stream gas utilization facilities is only one factor. There is apparently little flexibility in reducing the production of associated gases, because that is possible only if oil production is also limited -- but such a step may lead to a higher net oil import bill. In fact, it will be possible to limit the production of gas only from fields which have free gas reserves (e.g. South Basin). The production profile from such fields may be adjusted to the extent gas can be utilized purposefully down-stream.

The petroliferous basins of India are considered to be good prospects for natural gas. Compared to the incremental gas-oil ratios of less than 1200 million cubic metres per million tonnes (mcm/mt) in all basins until 1985, it was over by 1989/90. To the extent new hydrocarbon discoveries will have associated gas reserves, it will become necessary to develop a suitable gas pipeline system and other down-stream facilities in a coordinated manner.

Besides investing in new fields to commence commercial scale production, oil production from old and depleting fields may also be sustained over a longer time period by applying suitable enhanced oil recovery (EOR) techniques. Until now, water flooding and gas injection have been used most often in India, although these techniques are not always suitable for all types of fields. Pilot tests for chemical flooding, miscible gas injection and thermal methods of EOR are also under way in various fields

Table II.2.9

Developmental drilling done by ONGC and OIL.

Year	On-Shore		Off-Shore		Total	
	Meterage drilled (km)	No. of wells	Meterage drilled (km)	No. of wells	Meterage drilled (km)	No. of wells
1970/71	112	50+3[P]	-	-	112	50+3[P]
1975/76	145	68+1[P]	9	5	154	73+1[P]
1976/77	133	58+1[P]	14	7	147	65+1[P]
1977/78	135	59+1[P]	28	15	163	74+1[P]
1978/79	126	46	-	-	126	46
1979/80	80	39+2[P]	29	13	109	52+2[P]
1980/81	71	38+2[P]	42	18	113	56+2[P]
1981/82	145	63+4[P]	72	34	217	97+4[P]
1982/83	156	71+4[P]	105	47	261	118+4[P]
1983/84	181	79+2[P]	149	68	330	147+2[P]
1984/85	180	82+1[P]	109	51	289	133+1[P]
1985/86	272	124	89	44	361	168
1986/87	369	180+8[P]	116	35	485	215+8[P]
1987/88	388	199	161	52	549	251
1988/89	474	230	114	83	588	313
1989/90	593	315	193	73	786	388
1990/91*	455	220	92	66	547	286

* Provisional.

[P] Partly Drilled.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.10

Production of crude oil ('000 tonnes).

Year	Onshore				Offshore	Total
	Arunachal Pradesh	Assam	Gujarat	Tamil Nadu	Bombay High	
1970/71	-	3367	3455	-	-	6822
1971/72	-	3630	3669	-	-	7299
1972/73	-	3609	3712	-	-	7321
1973/74	-	3589	3600	-	-	7189
1974/75	-	3814	3870	-	-	7684
1975/76	-	4300	4148	-	-	8448
1976/77	-	4305	4187	-	406	8898
1977/78	-	4534	4155	-	2074	10763
1978/79	-	4085	4238	-	3310	11633
1979/80	-	3578	3766	-	4422	11766
1980/81	2	1712	3808	-	4985	10507
1981/82	2	4795	3422	-	7975	16194
1982/83	1	5000	3185	-	12877	21063
1983/84	31	5009	3588	-	17392	26020
1984/85	51	4893	3910	-	20136	28990
1985/86	60	4966	4319	-	20823	30168
1986/87	51	5239	4561	5	20618	30474
1987/88	36	5154	4989	14	20164	30357
1988/89	35	5457	5405	31	21112	32040
1989/90	38	5812	6313	208	21716	34087
1990/91	43	5076	6398	313	21191	33021

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.11

Gross production of natural gas (million cubic metres).

Year	Onshore			Offshore	Total
	Assam	Gujarat	Tripura	Bombay High	
1970/71	980	465	-	-	1445
1971/72	1012	523	-	-	1535
1972/73	1034	531	-	-	1565
1973/74	1195	518	-	-	1713
1974/75	1388	653	-	-	2041
1975/76	1595	773	-	-	2368
1976/77	1558	822	-	48	2428
1977/78	1717	893	-	229	2839
1978/79	1518	908	-	386	2812
1979/80	1385	840	-	542	2767
1980/81	843	842	-	673	2358
1981/82	1748	758	-	1345	3851
1982/83	1829	750	-	2357	4936
1983/84	1954	748	-	3259	5961
1984/85	2058[a]	775	-	4408	7241
1985/86	2335[a]	919	-	5180	8134
1986/87	2155[a]	971	22	6705	9853
1987/88	2160[a]	1005	43	8259	11467
1988/89	2178[a]	1258	50	9731	13217
1989/90	2182[a]	1613	106	13088	16989
1990/91[*]	2040[a]	2159	180	14082	17998

[*] Provisional.

[a] Includes one million cubic metres (mcm) of natural gas production from Arunachal Pradesh in 1984-85 and 6 mcm of natural gas in 1985-86 and 13 mcm in 1986-87, 1987-88, 18 mcm in 1988-89 and 23 mcm in 1989-90.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.12
Ratio of proven and balance recoverable reserves to production.

Year	Crude oil	Natural gas*
1971	15.83	41.28
1972	16.98	39.97
1973	17.69	39.69
1974	16.62	35.38
1975	17.37	37.95
1976	31.81	75.83
1977	29.77	83.81
1978	30.79	95.98
1979	27.61	111.61
1980	38.97	169.43
1981	31.41	117.80
1982	23.81	90.07
1983	20.93	82.39
1984	18.29	70.12
1985	16.73	60.52
1986	17.91	52.53
1987	19.29	49.59
1988	20.22	45.33
1989	21.56	40.65

* With respect to gross production of natural gas.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.13 Gross and net production of natural gas (million cubic metres).

	Gross prodn	Reinjected	Flared	Net production
Gujarat (onshore)				
1970/71	465	-	155	310
1985/86	919	-	118	801
1987/88	1005	-	268	737
1989/90	1613	-	478	1135
1990/91	1696	-	402	1294
Assam (onshore)				
1970/71	980	36	607	337
1985/86	2035	66	887	1082
1987/88	2203**	54	738	1411
1989/90	2288**	96	740	1452
1990/91	2220**	102	621	1387
Bombay High (offshore)				
1970/71	-	-	-	-
1985/86	5180	-	2113	3067
1987/88	8259	-	2439	5820
1989/90	13088	-	4503	8585
1990/91	14082	-	4047	10035
Total				
1970/71	1445	36	762	647
1985/86	8134	66	3118	4950
1987/88	11467	54	3445	7968
1989/90	16989	96	5721	11172
1990/91	17998	102	5130	12766

** includes Tripura/Tamil Nadu and Arunachal Pradesh

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Refining capability and consumption of petroleum products

Since the early 1970s at least, refining capacity has increased more-or-less to keep pace with the rising demand for petroleum products. However, total refinery output has always remained less than the consumption of refined products. And Indian refineries have processed not only indigenous crudes, but imported crudes also. Consequently, India has imported not only crudes, but refined products as well.

The sales/consumption of petroleum products increased from 17.9 mt in 1970/71 to 54.8 mt in 1990/91. This was due partly to an increase in economic activity. However, persistent shortages in coal supply and electricity -- particularly during the last ten years -- also resulted in an increased demand for petroleum products. Electric power shortages prompted several industrial and commercial establishments to install diesel generators, and agricultural consumers to install diesel pumpsets for stand-by use. Furthermore, certain pricing policies, such as subsidization of kerosene, contributed to a rise in kerosene demand for household cooking thus making soft-coke production unprofitable. The share of middle distillates in the consumption mix rose due to various reasons. One reason is that the Government has not allowed the price differential between kerosene and diesel to become too high (apparently to ensure that diesel is not adulterated by kerosene). As a result, certain private automobile users have preferred to retrofit their petrol driven cars by even inefficient diesel engines. Other factors (rising share of traffic through diesel using buses and trucks, dieselization of railways, increasing reliance on tractors for land preparation in agriculture and so forth) have also contributed to a growth of the share of middle distillates in the product demand mix. From about 50% in 1970/71, their share increased to about 55% by 1980/81, and further on to over 60% by 1989/90. However, the share of middle distillates in the refinery product mix remained fairly steady at 50-52% during the 1970s.

It is in this context that the Government sought to rationalize refineries during the Sixth FYP period. With addition to cracking capacity, the share of middle distillates rose to over 55% in 1989/90. Such efforts are planned to continue. Besides, delayed coker and fluidized catalytic cracker (FCC) facilities that already exist, there are plans to install hydrocracker (HC) units also. An HC unit is being installed at the IOC refinery at Koyali. Two new grassroot refineries (at Karnal and Mangalore) are also planned to have HC units.

Table II.2.14

Refining Capacity (million tonnes per annum).

Refining company	Location	Year of commissioning	Capacity on		
			Date of commissioning	April 1, 1971	April 1, 1990
BPCL	Bombay	1955	2.2	5.25	6.0
BRPL	Bongaigaon	1979	1.0	-	1.35
CRL	Cochin	1966	2.5	2.5	4.5
HPCL	Bombay	1954	N.A.	3.5	3.5*
HPCL	Vizag	1957	N.A.	1.5	4.5
IOC	Barauni	1964	2.0	3.0	3.3
IOC	Digboi	1901	0.5	0.5	0.5
IOC	Gauhati	1962	0.75	0.8	0.85
IOC	Haldia	1974	2.5	-	2.75
IOC	Koyali	1965	2.0	4.3	9.5
IOC	Mathura	1982	6.0	-	7.5
MRL	Madras	1969	2.5	2.5	5.6

Note: Three new grass-root refineries will be set up during the Eighth FYP period: (i) at Karnal, of 6 mtpa throughput capacity; (ii) at Mangalore, of 3 mtpa capacity; and (iii) A New Assam Refinery of 3 mtpa capacity. The refineries at Karnal and Mangalore will have HC units.

* Excludes 2 mtpa of Swing Refinery Capacity available at HPCL, Bombay.

Source: [1] Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

[2] Current Energy Scene in India, CMIE, July 1990.

Table II.2.15

Refining industry - crude throughput and production of petroleum products.

	1975/76	1979/80	1981/82	1983/84	1985/86	1986/87	1987/88	1988/89	1989/90
Crude throughput ('000 t)	22283	27474	30146	35263	42910	45698	47744	48803	51942
Capacity utilization (%)	76.0	81.1	76.9	87.1	87.5	91.6	98.0	93.6	93.7
Production ('000t)	20829	25794	28182	32926	39881	42776	44634	45699	48690
Refinery losses ('000 t)	1454	1680	1964	2337	3029	2922	3110	3104	3252
% Losses	6.5	6.1	6.5	6.6	7.1	6.4	6.5	6.4	6.3

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.16

Refining industry -- capacity utilization and losses (1989/90)*.

Refinery	Crude throughput ('000 tonnes)	Capacity utilization (%)	Refinery producton ('000 tonnes)	Refinery losses ('000 tonnes)	% losses
BPCL, Bombay	7037	117.2	6728	309	4.4
BRPL, Bongaigaon	1214	89.9	1005	209	17.2
CRL, Cochin	4616	102.6	4344	272	5.9
HPCL, Bombay	5755	164.4	5520	235	4.1
HPCL, Vizag	4280	95.1	3976	304	7.1
IOC, Barauni	2964	89.8	2709	255	8.6
IOC, Digboi	570	114.0	544	26	4.6
IOC, Gauhati	856	100.7	801	55	6.4
IOC, Haldia	2824	102.7	2560	264	9 3
IOC, Koyali	9109	95.9	8544	565	6.2
IOC, Mathura	7208	96.1	6814	394	5.5
MRL, Madras	5510	98.4	5096	414	7.5

* Provisional.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.17
Refinery production ('000 tonnes).

Products	1970/71	1979/80	1983/84	1987/88	1988/89	1989/90	1990/91*
Light distillates	**3021**	**4459**	**6134**	**9245**	**9451**	**10021**	**9813**
LPG	169	406	514	1026	1034	1179	1222
Mogas	1526	1512	1937	2662	2822	3328	3545
Naphtha	1205	2415	3578	5462	5378	5227	4658
Middle distillates	**8562**	**13080**	**16873**	**24563**	**25362**	**26867**	**26552**
Kerosene	2896	2539	3528	5104	5201	5700	5472
ATF	710	1104	1195	1695	1753	1575	1801
HSD	3840	7975	10862	16296	16656	17737	17186
LDO	986	1230	1081	1259	1468	1540	1509
Heavy ends	**5527**	**8255**	**9919**	**10870**	**10886**	**11802**	**12202**
Fuel Oils	4090	6351	8000	8466	8171	8952	9426
Furnace Oil	2987	4086	4588	4563	4243	4543	4878
LSHS	1103	2265	3412	3903	3928	4409	4548
Lube Oils	231	487	470	478	497	547	561
Petroleum Coke	151	99	136	257	275	275	238
Bitumen	805	1103	1069	1370	1548	1671	1603
Total production	**17110**	**25794**	**32926**	**44728**	**45699**	**48690**	**48567**

* Provisional.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.18

Refinery output mix (%).

	1970/71	1975/76	1979/80	1985/86	1986/87	1987/88	1988/89	1989/90*
Light distillates	17.6	17.4	17.3	20.7	21.2	20.7	20.7	20.6
Middle distillates	50.1	51.7	50.7	54.2	54.5	54.9	55.5	55.2
Heavy ends	32.3	30.9	32.0	25.1	24.3	24.4	23.8	24.2

* Provisional.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.19

Sales/Consumption of Petroleum Products ('000).

Products	1970/71	1975/76	1979/80	1985/86	1987/88	1988/89	1989/90	1990/91
Light distillates	**2697**	**3596**	**4460**	**6766**	**7547**	**8619**	**9412**	**9781**
LPG	176	336	410	1241	1686	1962	2268	2417
Mogas	1453	1275	1490	2275	2810	3052	3491	3540
Naphtha	904	1836	2413	3106	2852	3364	3350	3434
Middle distillates	**9040**	**11653**	**16321**	**23948**	**28005**	**29955**	**32484**	**32993**
Kerosene	3283	3104	3952	6229	7231	7731	8239	8385
ATF	689	897	1154	1453	1654	1713	1775	1689
HSD	3837	6595	8638	14886	17657	18795	20706	21079
LDO	1092	878	1216	1123	1245	1437	1486	1477
Heavy ends	**6175**	**7198**	**9102**	**10148**	**10864**	**11518**	**12199**	**11998**
Fuel Oils	4664	5781	7081	7900	8144	8456	8820	
Furnace Oil	3513	4279	4796	3806	4191	4605	4490	4329
LSHS	962	1381	2268	4094	3953	3851	4330	4516
HHS	163	121	17	-	-	-	-	-
Lubes and greases	545	441	566	700	791	847	926	910
Lube oils	523	425	546	658	756	811	888	
Greases	22	16	20	42	35	36	38	
Bitumen	777	690	1069	1126	1379	1498	1695	1574
Petroleum								
Coke	107	151	185	163	246	316	383	291
Other misc.	82	135	201	259	304	401	375	378
Total	**17912**	**22447**	**29883**	**40862**	**46416**	**50092**	**54095**	**54772**

* Provisional.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.20
Sales/consumption mix of petroleum products (%).

Product	1970/71	1975/76	1979/80	1985/86	1987/88	1988/89	1989/90	1990/91*
Light distillates	15.0	16.0	14.9	16.5	16.3	17.2	17.3	17.9
Middle distillates	50.5	51.9	54.6	58.6	60.4	59.8	60.1	60.2
Heavy ends	34.5	32.1	30.5	24.9	23.3	23.0	22.6	21.9

* Provisional.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Petroleum imports and exports

India is a net oil importer whose oil import bill has increased substantially during the past two decades. From less than 9% of foreign exchange earnings through commodity exports during the 1960s, the net oil import bill increased to over 30% in 1973/74 (following the first oil crisis), and then to over 75% in 1980/81 (after the second oil crisis).

This occurred despite an increase in relative self-sufficiency in oil supplies, from a mere 6% in 1960/61 to over 30% during the 1970s. Although the net oil import bill is reported to have reduced substantially since 1980/81, this is due largely to: (i) a rapid increase in indigenous crude production, as self-sufficiency in oil supplies increased to over 60% by 1983/84; and (ii) weak oil prices in the international market.

Table II.2.21

Imports/exports of crude oil.

Year	Quantity ('000 tonnes)			Value (Rs. million)		
	Imports	Gross exports	Net imports	Imports	Gross exports	Net imports
1970/71	11683	-	11683	1067.2	-	1067.2
1971/72	12951	-	12951	1470.2	-	1470.2
1972/73	12084	-	12084	1463.7	-	1463.7
1973/74	13873	18	13855	4163.9	4.2	4159.7
1974/75	14016	-	14016	9169.9	-	9169.9
1975/76	13624	-	13624	10517.6	-	10517.6
1976/77	14048	-	14048	11759.1	-	11759.1
1977/78	14507	-	14507	12462.0	-	12462.0
1978/79	14657	-	14657	12511.7	-	12511.7
1979/80	16121	-	16121	21875.3	-	21875.3
1980/81	16248	-	16248	33489.7	-	33489.7
1981/82	15298	838	14460	37363.8	1962.3	35401.5
1982/83	16949	4552	12397	40437.4	10633.7	29803.7
1983/84	15967	5522	10445	35410.5	12311.0	23099.5
1984/85	13642	6478	7164	34303.4	15631.6	18671.8
1985/86	15144	528	14616	36868.0	1351.5	35516.5
1986/87	15476	-	15476	21201.5	-	21201.5
1987/88	17732	-	17732	29863.1	-	29863.1
1988/89	17811	-	17811	28628.0	-	28628.0
1989/90	19490	-	19490	40895.0	-	40895.0
1990/91*	20699	-	20699	6118.4	-	6118.4

* Provisional.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.22
Imports and exports of petroleum products.

Year	Quantity ('000 tonnes)			Value (Rs. million)		
	Gross imports	Exports	Net imports	Gross imports	Exports	Net imports
1970/71	1084	332	752	299.1	46.7	252.4
1971/72	2147	136	2011	468.8	39.1	429.7
1972/73	3525	126	3399	605.8	81.6	524.2
1973/74	3548	161	3387	1245.0	80.5	1164.5
1974/75	2648	175	2473	1950.0	174.6	1775.4
1975/76	2218	170	2048	2043.4	139.6	1903.8
1976/77	2624	74	2550	2482.3	68.9	2413.4
1977/78	2879	47	2832	3053.4	56.9	2996.5
1978/79	3878	44	3834	4299.9	41.1	4258.8
1979/80	4724	88	4636	10823.9	240.2	10583.7
1980/81	7289	36	7253	19175.2	84.1	19091.1
1981/82	4884	55	4829	14531.6	151.3	14380.3
1982/83	5028	795	4233	15539.4	1337.9	14201.5
1983/84	4328	1472	2856	12707.5	3569.6	9137.9
1984/85	6092	933	5159	19149.1	2550.3	16598.8
1985/86	3865	1963	1902	12736.0	5095.7	7640.3
1986/87	3047	2491	556	6526.9	4112.3	2414.6
1987/88	4151	3412	739	10243.2	6487.5	3755.7
1988/89	6495	2295	4200	15598.4	5236.3	10362.1
1989/90	6564	2593	3971	22547.1	6955.6	15591.5
1990/91	8660	2648	6012	46602.1	10039.2	36562.9

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Storage of crude oil and refined products

Stock building and drawdown have influenced the evolution of the international oil market considerably in the past. In India, strategic storage of oil and its products is seen to provide some immunity from a sudden scarcity of oil in the international market and from large fluctuations in its price.

Strategic storage of oil to meet its demand for about 3 months is seen to provide an adequate balance between high costs of storage and risks of no storage at all. In keeping with the rising petroleum demand in India, the stocks of crude oil have been built up gradually during the past five-six years. Year end stocks of refined products have however, fluctuated in the 1980s, although the overall trend shows an increase.

It may be mentioned that the need for storage is influenced most by the level of indigenous demand for products, rather than by refining capacity. Therefore, the actual refinery expansion programme is not likely to influence the storage capacity expansion programme substantially.

Table II.2.23

Crude oil stock changes ('000 tonnes).

Year	**Addition (+)/Depletion (-)**
1970/71	126
1974/75	(-)204
1976/77	(-)49
1978/79	316
1980/81	916
1982/83	302
1984/85	596
1986/87	313
1988/89	1048
1989/90	1640

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.24

Changes in stocks of petroleum products[a] ('000 tonnes).

	1980/81	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90[*]
Light distillates	**(-)2**	**(-)208**	**(-)159**	**(-)287**	**(-)525**	**(-)770**	**(-)990**	**(-)1459**
Naphtha	(-)15	2	71	38	2	8	30	(-)55
Others	13	(-)210	(-)230	(-)325	(-)527	(-)762	(-)1020	(-)1404
Middle distillates	**443**	**159**	**(-)23**	**1366**	**272**	**(-)69**	**423**	**295**
HSD/LDO	299	37	(-)53	789	127	(-)107	240	133
Others	144	122	30	577	145	38	183	162
Heavy ends	39	(-)10	(-)219	318	(-)92	(-)362	137	(-)291
Total	**480**	**(-)59**	**(-)401**	**1397**	**(-)345**	**(-)1201**	**(-)430**	**(-)1455**

[a] Addition to Stocks (+)/Depletion (-).

[*] Provisional.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Natural gas and LPG

Natural gas was either flared or reinjected (for secondary recovery) during the 1950s and 1960s. It began to be used as an energy source outside the producing company (for example for power generation), or as a feedstock for the fertilizer and petrochemical industries only during the 1960s. A steady growth of down-stream utilization of natural gas is evident, although laige quantities still continue to be flared.

As LPG is a clean fuel that can be used for domestic cooking, the Government has plans to increase its supplies considerably. During the 1970s, LPG was obtained entirely from refinery flue gases. With the commissioning of LPG extraction plants in Bombay (Maharashtra) and Duliajan(Assam) in 1981 and 1982 respectively, LPG is now extracted from natural gas (while the lean gas is fed to fertilizer plants or utilized elsewhere). Other LPG extraction plants at Hazira and Uran have also come on-stream.

At present, LPG is distributed through retailers and agents by the marketing divisions of the Indian Oil Corporation (IOC), Bharat Petroleum Corporation Ltd. (BPC), Hindustan Petroleum Corporation Ltd. (HPCL) and the Indo-Burma Petroleum (IBP) Company Ltd. In addition to the four metropolitan cities (Bombay, Caluctta, Delhi and Madras), the LPG distribution network has now extended to several smaller towns and cities.

Table II.2.25

Industry-wise offtake of natural gas (million cubic metres).

Year	Energy purposes						Non-energy purposes			
	Power generation	Industrial fuel	Tea plantation	LPG shrinkage	Domestic fuel	Captive use	Fertilizer industry	Petro-chemicals	Others	Total
1970/71	261	116	15	-	-	68	187	-	-	647
1971/72	313	129	19	-	-	61	196	-	-	718
1972/73	339	148	20	-	Neg	63	201	-	-	771
1973/74	323	157	22	-	Neg	81	179	-	-	762
1974/75	354	164	29	-	6	80	318	-	-	951
1975/76	366	143	33	-	13	104	463	-	2	1124
1976/77	344	155	38	-	15	142	663	-	24	1381
1977/78	372	165	39	-	13	171	673	9	22	1464
1978/79	560	175	43	-	13	176	721	5	18	1711
1979/80	514	156	39	-	13	174	755	7	18	1676
1980/81	492	163	45	-	14	176	611	5	16	1522
1981/82	612	166	47	37	15	327	991	8	19	2222
1982/83	1025	185	51	100	14	399	1155	7	21	2957
1983/84	1209	230	56	161	16	411	1283	10	23	3399
1984/85	1454	250	62	190	18	531	1603	11	22	4141
1985/86	1299	223	78	275	21	520	2500	10	24	4950
1986/87	2041	257	93	366	25	929	3335	-	26	7072
1987/88	2721	281	99	-	34	1313**	3490	-	30	7968
1988/89	3145	370	120	-	48	1390	4132	-	45	9250

** Also includes LPG shrinkage.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Table II.2.26

Production and distribution of LPG.

	1981/82	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Production ('000 tonnes)							
Total	483	1230	1489	1584	1760	1948	2144
from refineries	410	867	995	1026	1034	1179	1222
from natural gas	73	363	494	558	726	769	922
No. of distributors	1169[b]	2742[c]	3066[c]	3307[c]	N.A.	3765	N.A.

[c] as on Apr.1.

Source: Department of Petroleum and Natural Gas, Annual Petroleum and Natural Gas Statistics, 1989/90, GOI, New Delhi.

Power

Installed capacity in utilities

Power generating capacity which is owned and operated by utilities, has grown at the rate of over 9.7% per annum since 1950. Of the 64818 MW commissioned until March 31, 1991, more than 50% had been added during the past ten years alone. During the Sixth FYP period, approximately 3000 MW were commissioned every year; and during the Seventh FYP period, about 4000 MW.

The hydro-thermal mix has changed substantially since the early seventies. In 1970/71, the installed hydro capacity was over 80% of the total thermal capacity installed (i.e. including coal based steam thermal power stations, gas turbines and diesel generators). By 1980/81, hydro capacity had fallen to 67% of thermal capacity; and by 1990/91, it reduced further to 41%. It is not easy to judge an optimal or desirable hydro-thermal mix, as it may depend upon the system load curve, performance of various types of plants and so on. However, it is believed that efforts must be made to increase the share of hydro capacity in future years.

Perhaps one of the most important reasons for the decline in the share of hydro capacity is that its gestation period is considerably longer than that of thermal capacity. Although there have been time over-runs in commissioning both hydro and thermal projects in the past, such delays have been usually less for the latter projects. This is because equipment and construction procedures for thermal projects are largely independent of site conditions, and can therefore be standardized. Such standardization however, may not be possible for hydro power plants. Another factor which has delayed the development of hydel power is inter-state water disputes. At present 27 projects with a capacity of 2584 MW are pending due to non-settlement of inter-state water disputes (CMIE, CES 1990).

India has also expanded its nuclear, and small hydro capacity over the past two decades. These aspects are discussed further in section on nuclear power and in chapter V respectively.

Table II.3.1

Installed capacity (GW) in utilities.

Year	Type			Total
	Hydel	*Thermal*[a]	*Nuclear*	
1950	.56	1.15	-	1.71
1955	.94	1.76	·	2.70
1960/61	1.92	2.74	-	4.65
1965/66	4.12	4.90	-	9.03
1970/71	6.38	7.91	.42	14.71
1975/76	8.46	11.01	.64	20.12
1980/81	11.79	17.56	.86	30.21
1981/82	12.17	19.31	.86	32.35
1982/83	13.06	21.45	.86	35.36
1983/84	13.86	24.39	1.20	39.34
1984/85	14.46	27.03	1.10	42.59
1985/86	15.47	29.97	1.33	46.77
1986/87	16.20	31.74	1.33	49.27
1987/88	17.27	35.56	1.33	54.16
1988/89	17.80	39.68	1.57	59.04
1989/90	18.63	43.74	1.57	63.62
1990/91	18.44	44.91	1.47	64.82

[a] Includes coal based steam thermal plants, gas

Sources : [1] Central Electricity Authority. Public Electricity Supply, All India various issues; and [2] CEA. Power Supply Position in the Country, Vol 17, No. 5, New Delhi, May 1989.

Table II.3.2

Installed capacity in utilities by region As on March 31 of each year (%).

	1971	1977	1980	1984	1987	1988	1989*
A Northern region(MW)	**3152.55**	**5634.28**	**8224.02**	**11179.78**	**13462.44**	**15344.92**	**17470.97**
Hydro	61.37	47.90	47.99	42.68	38.79	36.59	34.14
Steam thermal	34.83	45.91	48.36	52.85	56.32	59.24	59.06
Diesel & wind	3.40	1.89	0.83	0.54	0.36	0.13	0.12
Gas	0.40	0.40	0.15	0.00	1.34	1.17	2.82
Nuclear	0.00	3.90	2.68	3.94	3.27	2.87	3.86
B Western Region (MW)	**4023.83**	**5607.05**	**7808.52**	**11975**	**14680.63**	**16533.31**	**17818.31**
Hydro	28.12	29.75	22.93	15.12	14.19	13.22	12.51
Steam thermal	59.09	61.71	70.96	78.90	77.98	79.83	81.03
Diesel & wind	1.02	0.08	0.04	0.02	0.02	0.03	0.02
Gas	1.34	0.96	0.69	2.46	4.95	4.39	4.07
Nuclear	10.44	7.49	5.38	3.51	2.86	2.54	2.36
C Southern region (MW)	**4034.71**	**5634.22**	**7207.31**	**9397.81**	**12488.55**	**13224.84**	**14567.19**
Hydro	70.40	66.72	63.73	63.13	59.99	59.03	54.49
Steam thermal	29.04	32.88	35.97	33.60	36.21	37.37	42.24
Diesel & wind	0.07	0.05	0.02	0.02	0.03	0.04	0 05
Gas	0.50	0.35	0.28	0.21	0.00	0.00	0 00
Nuclear	0.00	0.00	0.00	2.50	3.76	3.55	3.23
D Eastern region (MW)	**3305.47**	**4327.52**	**4866.74**	**6076.88**	**7741.42**	**8068.28**	**8161.21**
Hydro	12.39	18.95	18.63	16.13	13 96	15.37	15.23
Steam thermal	86.56	80.16	16.81	81.44	84.15	82.78	81.82
Diesel & wind	1.06	0.89	0.86	0.78	0.61	0.61	0.61
Gas	0.00	0.00	2.05	1.65	1.29	1.24	2.33
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00

contd .

Table II.3.2 (contd.)

Installed capacity in utilities by region As on March 31 of each year (%).

	1971	1977	1980	1984	1987	1988	1989*
E North-eastern region (MW)	**192.39**	**265.52**	**341.24**	**709.39**	**892.82**	**983.82**	**1022**
Hydro	34.99	29.67	43.13	43.81	35.62	42.53	41.23
Steam thermal	0.00	24.48	18.32	26.08	36.63	33.24	34.93
Diesel & wind	22.65	15.16	14.67	9.32	8.43	6.70	6.96
Gas	42.36	30.69	23.88	20.79	19.32	17.53	16.88
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F All India (MW)	**14708.95**	**21468.59**	**28447.83**	**39338.86**	**49265.86**	**54155.17**	**59039.68**

* Provisional.

A Includes Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, Uttar Pradesh, Chandigarh and Delhi.

B Includes Gujarat, Madhya Pradesh, Maharashtra, Goa, Daman-Diu, Dadra and Nagar Haveli.

C Includes Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Pondicherry and Lakshadweep.

D Includes Bihar, Orissa, West Bengal, DVC, Andaman and Nicobar Islands and Sikkim.

E Includes Assam, Manipur, Meghalaya, Tripura, Arunachal Pradesh, Mizoram and Nagaland.

Sources : [1] Central Electricity Authority. Public Electricity Suply, All India Statistics General Review, various issues; and [2] CEA. Power Supply Position in the Country, Vol. 17, No. 5, New Delhi, May 1989.

Table II.3.3

Statewise installed generating capacity: March end 1990.

(MW)

	Thermal	Nuclear	Hydel	Total
Major States				
Andhra Pradesh	3525.5	-	2468.7	5994.2
Assam	539.0	-	-	539.0
Bihar	1300.0	-	150.0	1450.0
Gujarat	3787.0	-	305.0	4092.0
Haryana	830.0	-	48.0	878.0
Karnataka	420.0	-	2210.4	2630.4
Kerala	-	-	1476.5	1476.5
Madhya Pradesh	5932.5	-	205.0	6137.5
Maharashtra	6616.0	320	1637.0	8573.0
Orissa	460.0	-	1070.0	1530.0
Punjab	1280.0	-	511.0	1791.0
Rajasthan	1053.0	440	420.0	1913.0
Tamil Nadu	3150.0	470	1938.0	5558.0
Uttar Pradesh	7569.5	235	1422.4	9226.9
West Bengal	3058.0	-	41.3	3099.3
Himachal Pradesh	-	-	442.9	442.9
Jammu & Kashmir	97.5	-	523.0	620.5
Other States				
Manipur	-	-	105.0	105.0
Meghalaya	-	-	275.2	275.2
Sikkim	-	-	12.0	12.0
Tripura	-	-	15.0	15.0
Bakra & Beas Mgmt.Board	-	-	2705.0	2705.0
Damodar Valley Corpn	1730.0	-	104.0	1834.0
Union Territory				
Delhi	1311.5	-	-	1311.5
All India	**42659.5**	**1465.0**	**18085.4**	**62209.9**

Note: The above capacity is in respect of the generating stations being monitored by the CEA.

Source : CEA, Bulletin on Power Supply Position in the Country:March 1990, New Delhi.

Table II.3.4
Gestation period (months) of power projects.

Commissioning year	Average gestation period				Number of units			
	Hydel	*Thermal*	*Gas*	*Nuclear*	*Hydel*	*Thermal*	*Gas*	*Nuclear*
1980/81	79	83	-	155	7	8	-	1
1981/82	114	80	56	-	4	9	4	-
1982/83	113	84	59	-	9	12	2	-
1983/84	145	74	81	187	17	16	1	1
Average	**121**	**79**	**60**	**171**	**37**	**45**	**7**	**2**

Source : Planning Commission, Paper on "Gestation Period for Commissioning of Hydel, Thermal and Nuclear Power Projects".

Table II.3.5

Gas-based power projects (GPP) in the eighth plan*

(MW)

Name of the project	Installed capacity	Benefits during the 8th Plan
Central sector		
Kawas (GPP), Gujarat	4x100 + 2x100	600
Kathalguri (GPP), Assam	6x131 + 3x30	270
Dadri (GPP), Utttar Pradesh	4x131 + 2x146	816
Anta (GPP)Extn., Uttar Pradesh	3x100 + 3x10	430
Gandhar (GPP),Gujarat	650	650
Godavari (GPP), Andhra Pradesh	800	800
Rokhia (GPP), Tripura	10x8	80
Faridabad (GPP), Haryana	4x130 + 2x140	800
Tripura (GPP), Tripura	500	500
State sector		**4,947.2**
Urban Waste Heat (W.H.)	3x120	360
Vijjeshwaram (GPP)(Unit-3)	2x33 + 1x33	33
Lakwah Phase-II, Assam	3x20	60
Lakwah W.H., Assam	1x22	22
Ramgarh, Rajasthan	1x3	3
Vatwa (GPP), Gujarat	2x33.5 + 1x35	102
Utran (GPP), Gujarat	3x30 + 1x45	135
Gandhar (GPP), Gujarat	600	600
Piparvar (GPP), Gujarat	750	750
Karaikal (GPP), Pondicherry	3x5 + 1x7.5	22.5
Amguri (GPP), Assam	8x30 + 4x30	360
DESU W.H. Delhi	3x30	90
Total (A + B)		**7,484.7**

* refers to 1990-1995.

Source : Reply to Unstarred Question No.775 in the Rajya Sabha on March 1990.

Nuclear power

As on March 31, 1990, the installed nuclear capacity was 2.3% of total installed utility capacity, and its gross generation in 1990/91 was about 2.4% of total utility generation. Three nuclear power stations are in commercial operation at Tarapur (Maharashtra), Rowatbhata (Rajasthan) and Kalpakkam (Tamil Nadu) with a total installed capacity of

1230 MW. All are based on the heavy-water reactor technology. The functioning of the three nuclear power stations has been beset with problems in recent years. Large shut-down times have been reported, particularly in the nuclear station at Rajasthan.

Three new nuclear power stations are under construction at Narora in UP (2x235 MW), Kakrapar in Gujarat (2x235 MW) and Kaiga in Karnataka (2x235 MW); while two new units (235 MW each) are being added to RAPS. The three new nuclear power stations are expected to be commissioned in 1989/90, 1991/92 and 1995/96 respectively; and the expansion of RAPS is also expected to be completed by 1995/96.

The fourth nuclear power station at Narora (Uttar Pradesh) will have two pressurized heavy water reactor units of 235 MW each, using natural uranium as fuel. Although the plant at Narora was initially planned to be commissioned during 1981/82, it is now expected to be completed only by 1988/89. The major reasons for slippages in the construction schedule have been problems in acquiring land, delays in finalizing designs to suit seismic requirements, delays in fabricating certain critical equipment, and non-availability of certain construction materials.

With indigenously available natural uranium reserves, India can support a nuclear power programme of about 8000 MW (Report of the Working Group on Energy Policy, Government of India, 1979). Therefore, there is considerable scope for expanding the country's nuclear programme from present day levels. Efforts are being made in this direction. The potential of course, can multiply several-folds if the fast-breeder reactor technology is introduced.

In addition, India also has large thorium oxide reserves (about 363,000 tonnes), which can also support a large nuclear programme.

Table II.3.6

Decadal growth in nuclear.power: Installed capacity and generation.

	Installed capacity (MW)			Power generation (Mln. units)		
	Nuclear (1)	Total (2)	Col.(1) as % of Col.(2) (3)	Nuclear (4)	Total (5)	Col.(4) as % of Col.(5) (6)
1970-71	420	14709	2.9	2417	55827	4.3
1980-81	860	30214	2.8	3001	110844	2.7
1990-91	1465	64818	2.3	6244	264231	2.4

Source: Current Energy Scene in India, October 1991, CMIE.

Table II.3.7

Nuclear power projects (stations).

Project	Location (District/State)	Capacity (MW)
A. Under operation		**1,465**
Tarapur (APS) (unit 1 & 2)	Thane Maharashtra	2x160 = 320
Rajasthan (APS) (unit 1 & 2)	Kota Rajasthan	2x220 = 440
Madras (APS) (Unit 1 & 2)	Chengalpettu Tamil Nadu	2x235 = 470
Narora (APS) (Unit 1)*	Bulandshahr Uttar Pradesh	1x235 = 235
B. Sanctioned project under construction		**1,645**
Narora (APP) (Unit 2) (August-end 1990)	Bulandshahr Uttar Pradesh	1x235 = 235
		contd...

Table II.3.7 (contd.)
Nuclear power projects (stations).

Project	Location (District/State)	Capacity (MW)
Kakrapar (APP) (Unit 1&2) (Unit-1 June 1990; Unit-2 Dec.1991)	Surat Gujarat	2x235 = 470
Kaiga (APP) (Unit 3&4) (Unit-1 June 1995; Unit-2 Dec.1995)	Uttar Kannad Karnataka	2x235 = 470
Rajasthan (APP) (Unit 3&4) (Unit-3 May 1995; Unit-4 Nov.1995)	Kota Rajasthan	2x235 = 470
C. Approved for construction		**5,940**
Kaiga (APP) (Unit 3 to 6)	Uttar Kannad Karnataka	4x235 = 940
Tarapur (APP) (Unit 3 & 4)	Thane Maharashtra	2x500 = 1,000
Rajasthan (APP) (Unit 5 to 8)	Kota Rajasthan	4x500 = 2,000
Kundankulam (APP) (Unit 1 & 2)	Tirunelveli Tamil Nadu	2x1,000 = 2,000
Total : (A + B)		3,110
Total : (A + B + C)		**9,0E0**

Note: Achieved critically on 12 March 1989 and synchronised to the northern grid on 29 July 1989. Commercial operation of the unit is expected to commence during early part of 1990-91.

Source: Department of Atomic Energy, Annual Report : 1990-91, New Delhi.

Utility generation

Like for utility capacity, utility generation has also grown rapidly over the past four decades. The growth of gross generation averaged over 10% per annum between 1950 and 1988/89; and nearly doubled during the nine year period 1980/81 through 1989/90.

The hydro-thermal generation mix also changed substantially, particularly since 1970/71. While the ratio of hydro to thermal generation varied between 1:1 and 1:1.25 during the fifties and sixties, it began to decline steadily during the seventies. In 1986/87, it was 1:2.4; and in 1989/90, it was 1:2.9. One of the reasons for this relative increase in thermal generation is the comparatively smaller gestation periods for thermal projects -- which has led to a rise in the share of thermal capacity.

Another reason for a decline in the share of hydro generation is a gradual reduction

in the average utilization rate of hydro projects. This perhaps suggests that hydro plants are being used (on an average at the All India level) increasingly for peaking purposes. However, there may be significant differences between regions. For instance, in the Northern Region, the average gross generation from hydro projects increased from about 3400 KWh/kW in 1970/71 to about 3700 kWh/kW in 1987/88.

The average utilization rates of thermal power stations however, show no significant trends. While the average plant load factor of coal based thermal projects has remained below 54%, there are significant differences at the regional and state level. The reasons for and the implications of, such low plant load factors are discussed further in section on "Peak and energy deficits". The gas based power stations seem to be advantageous on account of shorter gestation periods and higher thermal efficiency. In addition, these stations are suitable for quick start up/stopping operations, if required and the capital investment on these projects is only 60-70% of the coal based stations.

The contribution of nuclear projects has already been discussed earlier.

Table II.3.8

Annual gross generation in utilities.

(GWh)

	Hydel	Thermal*	Nuclear	Total
1960/61	7836.58	9100.43	-	16937.01
1970/71	25248.24	28162.02	2417.38	55827.64
1980/81	46541.76	61300.86	3001.34	110843.96
1982/83	48373.38	79868.26	2021.94	130263.58
1984/85	53948.25	98836.30	4074.83	156859.38
1986/87	53840.86	128851.31	5021.74	187713.99
1987/88	47444.00	149614.00	5035.00	202093.00
1988/89	57793.00	157510.00	5822.00	221125.00
1989/90	62000.00	182800.00	7000.00	251300.00
1990/91[a]	71535.00	186452.00	6244.00	264231.00

* Includes gross generation from steam thermal plants, gas turbines and diesel generators.

[a] Provisional.

Sources: [1] Central Electricity Authority. Public Electricity Suply, All India Statistics General Review, various issues; and [2] Current Energy Scene in India, July 1990, CMIE.

Table II.3.9

Regionwise annual gross generation in utilities.

(GWh)

	1970/71	1976/77	1979/80	1982/83	1985/86	1986/87	1987/88	1988/89
Northern region	**11863**	**23858**	**29227**	**37077**	**46134**	**53147**	**59994**	**66674**
Hydro	55.77	48.05	52.95	49.99	42.66	41.44	34.78	35.35
Steam	43.93	47.31	43.15	48.52	54.55	55.79	62.15	61.44
Diesel	0.30	0.04	0.02	0.01	0.00	0.00	0.00	0.00
Gas	0.00	0.01	0.01	0.00	0.00	0.28	0.75	0.41
Nuclear	0.00	4.59	3.87	1.49	2.80	2.49	2.32	2.80
Western region	**16912**	**25981**	**32077**	**40188**	**57376**	**62733**	**68471**	**72833**
Hydro	32.39	29.45	24.77	16.30	10.36	9.81	7.40	10.35
Steam	52.89	61.85	69.55	77.19	84.26	82.89	86.51	84.40
Diesel	0.09	0.00	0.00	0.00	0.00	0.00	0.00*	0.00*
Gas	0.34	0.40	0.24	2.85	1.97	4.11	3.74	2.64
Nuclear	14.29	8.30	5.44	3.66	3.42	3.19	2.34	2.61
Southern region	**15710**	**21714**	**27032**	**33682**	**43496**	**46875**	**47457**	**54213**
Hydro	74.34	60.22	71.60	60.11	49.11	44.96	36.57	39.91
Steam	25.65	39.77	28.40	39.88	46.91	51.40	59.13	56.29
Diesel	0.00	0.00	0.00	0.01	0.00	0.02	0.02	0.02
Gas	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nuclear	0.00	0.00	0.00	0.00	3.98	3.62	4.29	3.78
North-eastern region	**10959**	**15977**	**15393**	**17922**	**21167**	**22982**	**23958**	**25159**
Hydro	12.01	15.37	15.16	14.30	13.98	15.97	13.33	14.96
Steam	87.70	84.55	83.99	84.41	85.78	83.76	86.43	84.66
Diesel	0.29	0.07	0.18	0.11	0.00	0.10	0.13	0.13
Gas	0.00	0.00	0.66	1.18	0.23	0.17	0.12	0.25
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All India	**55829**	**88333**	**104627**	**130264**	**170010**	**187717**	**202094**	**221395**

* Includes 1.56 GWh from Windmill

neg < 0.5 GWH.

Source: Central Electricity Authority. Public Electricity Suply, All India Statistics General Review, various issues.

Table II.3.10
Annual utilization (%).

	Hydel	Thermal*	Nuclear	Total
1970/71	45.15	40.66	65.7	43.33
1975/76	44.92	44.88	46.85	44.96
1980/81	45.06	39.84	39.84	41.88
1981/82	46.48	41.09	40.1	43.09
1982/83	42.29	42.51	26.84	42.05
1983/84	41.16	40.57	36.97	40.68
1984/85	42.59	41.74	42.48	42.05
1985/86	37.64	43.56	42.76	41.58
1986/87	37.96	46.37	43.10	43.51
1987/88	31.43	47.86	43.16	42.53
1988/89	37.48	44.19	49.78	42.33

Note: Utilization figures are computed using annual generation data only. This tends to under-estimate the annual utilization (kWh/kW) to the extent capacity additions take place during the year.

* Includes steam thermal capacity, gas turbines and diesel generators.

Source: CEA. Power Suply Position in the Country Vol 17, No. 5, New Delhi, May 1989.

Table II.3.11
Utilization of thermal power stations (%).

	1980/81	1987/88	1988/89
All India	**45.0**	**56.5**	**55.0**
State Electricity Boards/Departments			
Overall	NA	53.5	51.6
Andhra Pradesh	36.3	76.2	69.6
Punjab	37.6	71.5	56.0
Rajasthan	NA	71.5	52.5
Tamil Nadu	34.5	68.7	66.7
Karnataka	-	64.5	66.4
Gujarat	50.0	60.0	56.1
Maharashtra	52.6	57.0	53.4
Madhya Pradesh	52.4	53.3	50.1
Uttar Pradesh	36.5	47.1	54.7
Haryana	31.7	40.6	41.2
West Bengal	42.1	38.6	36.7
Bihar	31.4	33.0	37.1
Orissa	34.0	32.5	30.9
Assam	36.5	31.0	27.6
Delhi	60.0	49.1	44.7
Jammu & Kashmir	2.0	NA	NA
Central sector	**NA**	**63.3**	**62.6**
Private sector	**NA**	**67.6**	**63.2**

Source: Current Energy Scene in India, July 1990, CMIE.

Table II.3.12

Trends in sectorwise power consumption : 1970-71 to 1988-89 (utilities only).

(%)

	Domestic	Commercial	Industrial	Railways	Agriculture	Others
1970-71	8.8	5.9	67.6	3.2	10.2	4.3
1975-76	9.7	5.8	62.4	3.1	14.5	4.5
1976-77	9.5	6.2	62.5	3.3	14.6	4.1
1977-78	9.9	5.6	61.8	2.8	15.6	4.2
1978-79	9.8	5.6	61.8	2.8	15.6	4.4
1979-80	10.8	6.0	58.9	2.9	17.2	4.2
1980-81	11.2	5.7	58.4	2.7	17.8	4.4
1981-82	11.6	5.8	58.8	2.8	16.8	4.2
1982-83	12.7	5.7	58.4	2.7	17.6	4.4
1983-84	12.9	6.4	55.8	2.6	17.8	4.5
1984-85	13.6	6.1	55.2	2.5	18.4	4.2
1985-86	14.7	6.0	54.5	2.5	19.1	4.0
1986-87	14.2	5.9	52.5	2.4	20.7	4.3
1987-88	14.7	6.0	48.8	2.5	23.8	4.2
1988-89	15.0		48.0	-	24.0	-

SOURCE : [1] Ministry of Finance, Government of India, Economic Survey: 1989-90, New Delhi, 1990.

[2] Reply to Unstarred Question No. 1962 in the Rajya Sabha on 28th May 1990

Peak and energy deficits

The power supply situation in India is characterized by peak and energy shortages. Electricity peaking and energy deficits are expected to continue over the next few years. A peaking deficit of over 9,300 MW and an energy shortage of nearly 15,000 GWh are projected for 1989/90 (see CEA, Thirteenth Electric Power Survey of India, New Delhi, December 1987).

Perhaps the key reason for such shortages is the insufficiency of financial resources. However, it may be noted that since the mid-sixties, the outlay for the power sector has been rather high, at 15 to 20% of the total public sector outlay, and the scope for increasing its share is therefore limited. Consequently, the power industry has little choice but to enhance its internal resource generation.

One of the ways may be restructuring its tariffs in line with costs of power generation and supply. Another way may be to reduce slippages and delays in commissioning generation projects -- which in turn lead to cost over-runs as well. However, it has been observed that slippages in construction schedules are themselves a consequence of non-availability of sufficient financial resources.

Moreover, availability and plant load factors of thermal power projects, which are relatively low in India, also have a substantial scope for improvement. The availability of thermal power generating units in the developed countries is significantly higher than what may be considered as normative (for power sector planning) in India. This may be due to several factors: poor quality of coal used in boilers in India, lack of coal processing facilities, unavailability of a properly trained work force, inadequate or insufficient control equipment, and so forth. The fact that the peak availability norms adopted for planning purposes during the Seventh FYP period are lower than those of the Sixth FYP period, is only a reflection of the recognition of the difficulties experienced. It may be noted that these norms (for planning purposes) are quite different from the actual experience in the recent past from 1977/78 to 1982/83: planned maintenance 12.4%, forced outage rate 18.5%, partial outage rate 20% and auxiliary consumption 12%. It is therefore clear that the availability norms adopted even for the Seventh FYP period are based on an a priori assumption that the performance of thermal power stations will improve.

However, the peaking capability of stabilized thermal units is higher than that of newly established units. It is estimated that a thermal unit attains a stable peaking capability only after about a year of operation. Despite this, normative energy generation capability is expected to be achieved only after three years of operation. As thermal capacity has increased rather rapidly in recent years, a rather low average plant load factor that has been observed, may be due to this reason.

While peaking capability norms for thermal units are low, those for hydro units are substantially higher -- this reflects past experience. The planned unavailability of hydro units during peak time is taken as nil, only because their maintenance work can be scheduled during off-peak periods and in months/seasons when the system demand is

low

In recognition of the technical potential and the need to improve the performance of thermal power stations, GOI approved a Rs. 5000 million scheme in 1984, for renovation and modernization of 162 generating units in 34 selected stations. The performance of several thermal generating units has been upgraded following renovation and modernization.

Table II.3.13

Power requirement, supply and deficit/surplus (GWh).

Region	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91*
Northern region							
Requirement	44722	48504	55006	62891	65514	74243	78790
Availability	38471	43303	49807	55801	61629	69960	75520
Surplus(+)/Deficit(-)	(-)6251	(-)5201	(-)5199	(-)7090	(-)3885	(-)4283	(-)4270
Surplus(+)/Deficit(-)%	(-)14	(-)10.7	(-)9.5	(-)11.3	(-)5.9	(-)5.8	(-)5.4
Western region							
Requirement	46430	51311	57694	63135	66612	74737	81423
Availability	46118	50595	55263	60024	64872	72787	78502
Surplus(+)/Deficit(-)	(-)312	(-)716	(-)2431	(-)3111	(-)1740	(-)1950	(-)2921
Surplus(+)/Deficit(-)%	(-)0.7	(-)1.4	(-)4.2	(-)4.9	(-)2.6	(-)2.6	(-)3.6
Southern region							
Requirement	39729	45535	51178	55286	59931	65422	70658
Availability	39810	41298	45536	45927	64872	72787	62982
Surplus(+)/Deficit(-)	(+)81	(-)4237	(-)5642	(-)9359	(-)8250	(-)8702	(-)7676
Surplus(+)/Deficit(-)%	(+)0.2	(-)9.3	(-)11.0	(-)16.9	(-)13.8	(-)13.3	(-)10.9
Eastern region							
Requirement	22957	23643	26549	27560	28685	30598	32745
Availability	18982	20376	21860	24205	25354	26006	26678
Surplus(+)/Deficit(-)	(-)3975	(-)3276	(-)4689	(-)3355	(-)8250	(-)8702	(-)6067
Surplus(+)/Deficit(-)%	(-)17.3	(-)13.8	(-)17.7	(-)12.2	(-)11.6	(-)15.0	(-)18.5
North-eastern region							
Requirement	1594	1753	1929	2121	2452	2762	3016
Availability	1632	1690	1810	2019	2373	2678	2878
Surplus(+)/Deficit(-)	(+)38	(-)63	(-)119	(-)102	(-)79	(-)84	(-)138
Surplus(+)/Deficit(-)%	(+)2.4	(-)3.6	(-)6.2	(-)4.8	(-)3.2	(-)3.0	(-)4.6
All India							
Requirement	155432	170746	192356	210993	223194	247762	267632
Availability	145013	157262	174276	187976	105909	228151	246560
Surplus(+)/Deficit(-)	(-)10419	(-)13484	(-)18080	(-)23017	(-)15673	(-)17930	
Surplus(+)/Deficit(-)%	(-)6.7	(-)7.9	(-)9.4	(-)10.9	(-)7.7	(-)7.9	(-)7.9

*April 1, 1989 through Feb. 28, 1990.

Source: Current Energy Scene in India, July 10090, CMIE.

Table II.3.14

Plan-wise slippages in additional installed capacity.

Plan	Target (MW)	Achievement (MW)	Slippage (%)
First Plan			
1951 to 1956	1300	1100	15.4
Second Plan			
1956 to 1961	3500	2250	35.7
Third Plan			
1961 to 1966	7040	4520	35.8
Annual Plan			
1966 to 1969	5430	4120	24.1
Fourth Plan			
1969 to 1974	9264	4579	50.5
Fifth Plan			
1974 to 1979	12499	10202	18.4
Annual Plan			
1979/80	2945	1799	38.9
Sixth Plan			
1980 to 1985	19666	14226	27.7
Seventh Plan			
1985 to 1990	22245	21402	3.8
Annual Plan			
1990 to 91	4212	2776	34.1

Source: Current Energy Scene in India, October 1991, CMIE.

Table II.3.15

Finances of the power sector.

Plan	Total outlay (Rs. billion)	Share of power in total plan outlay (%)
Third Plan		
1961 to 1966	85.8	14.6
Annual Plan		
1966 to 1969	66.2	18.3
Fourth Plan		
1969 to 1974	157.8	18.6
Fifth Plan		
1974 to 1979	394.3	18.8
Annual Plan		
1979/80	128.8	18.4
Sixth Plan		
1980 to 1985	1092.9	16.7
1980/81	148.3	17.9
1981/82	182.1	17.5
1982/83	212.8	17.4
1983/84	250.9	16.3
1984/85	298.8	15.6
Seventh Plan		
1985 to 1990[a]	1800.0	19.1
1985/86[b]	330.6	17.0
1986/87[b]	391.5	17.1
1987/88[b]	429.2	16.5
1988/89[b]	480.7	17.2
1989/90[c]	570.2	19.0
Annual Plan		
1990 to 1991[a]	647.2	19.3

[a] Planned outlay.

[b] Actuals.

[c] Revised estimates.

Source: Current Energy Scene in India, July 1990, CMIE.

Table II.3.16
International standards for capacity planning for thermal power stations.

Equipment	**Availability (%)**	**Forced outage rate (%)**	**Planned maintenance rate (%)**
Boiler	85	7	8
Turbine	95	2	3
Generator	98	2	nil
Other			
Equipment	98	2	nil
Overall	**76**	**13**	**11**

Source: CEA, Report of the subgroup on Norms for Capacity Planning for the Seventh Plan, January 1984.

Table II.3.17
Peaking capability of stabilized thermal units.

Item	**Norms adopted for 1980-85 period (%)**	**Norms adopted for 1985-1990 period (%)**
Planned maintenance	3.5	5
Forced outrage rate*	18.5	17
Partial outrage rate	10.0	15
Auxiliary consumption	9.0	10
Spinning reserve	nil	5
Overall peak ability	**64.4**	**57.3**

* Higher by 5% in the Eastern and North-Eastern regions.
Source: Current Energy Scene in India, July 1990, CMIE.

Table II.3.18

Norms for energy generation from new thermal units*.

	kWh/kW per year
1st Year	2500
2nd Year	4000
3rd Year	5000
4th Year	5350

*Unit capacity of 210 MW and 500 MW.

Source: Current Energy Scene in India, July 1990, CMIE.

Table II.3.19

Peaking capability of hydro plants.

Item	**Norm (%)**
Planned maintenance	nil
Capital maintenance	3.0
Forced outage rate	9.5
Overall peak availability	87.8

Source: Current Energy Scene in India, July 1990, CMIE.

Table II.3.20

PLF of thermal units before and after renovation and modernization

(As on March 1, 1991).

	Unit No.	Capacity (MW)	PLF before renovation average fig. (%)	PLF after partial renovation Apr.-Dec., 1988
Badarpur	1	100.0	45.7	78.10
	3	100.0	57.2	66.50
	4	210.0	44.2	73.50
	5	210.0	37.0	66.80
Indraprastha	2	62.5	47.9	57.90
	3.	62.5	53.5	57.70
	5	60.0	50.3	73.10
Faridabad	1	60.0	28.8	78.70
	3	60 0	21.1	47 30
Bhatinda	1	110 0	48 0	60.80
	3	110 0	45 7	58.20
	4	110 0	52.6	59 90
Pankı	4	110 0	43.4	53.10
Obra	2	50.0	45.7	71 60
	6	100.0	37 9	56 00
	7	100.0	39 2	52 90
	9	200.0	33 3	72 00
	10	200.0	31.4	66 70
	11	200 0	28 4	58 90
	12	200.0	40.2	74.80
	13	200 0	35 1	73 80
Harduaganj (B&C)	6	60 0	38 1	43 60
Korba-II	1	50.0	61 0	78 80
	3	50.0	62.6	80.50
	4	50 0	52.5	71 60
Korba-III	1	120 0	41 4	47 70
	2	120 0	56 4	60.50
Satpura	1	62 5	51 5	59 00
Gandhınagar	2	120 0	48 2	62 80
Ukaı	2	120 0	38 7	65 50
Koradı	4	120 0	38 9	56 40
Kothagudam	1	60 0	40 0	58 40
	4	60.0	54 9	62.60

contd

Table II.3.20 (contd.)

PLF of thermal units before and after renovation and modernization

(As on March 1, 1991).

	Unit No.	Capacity (MW)	PLF before renovation average fig. (%)	PLF after partial renovation Apr.-Dec., 1988
	5	110.0	27.6	44.40
	6	110.0	23.2	55.00
	7	110.0	17.3	50.40
	8	110.0	34.2	47.00
Ramagundam	1	62.5	70.4	73.20
Ennore	1	60.0	51.0	68.10
	2	60.0	48.1	63.20
	4	110.0	25.2	50.30
	5	110.0	26.4	55.00
Tuticorin	1	210.0	46.0	66.50
	2	210.0	47.0	65.10
	3	210.0	40.4	82.70
Neyveli	3	50.0	71.1	80.60
	6	50.0	78.3	83.80
	8	100.0	68.2	84.70
	9	100.0	66.3	79.20
Talcher	1	62.5	33.7	65.60
Patratu	1	50.0	32.8	51.40
	2	50.0	25.2	62.80
Santaldih	4	120.0	34.1	56.20
DPL	3	70.0	00.0	22.20

Source: Department of Power, Ministry of Energy, Annual Report 1990-91.

Non-utility generation

Owing to peak and energy deficits in the utility power supply, and the stated Government policy of preferential power supply to rural areas, several industrial and commercial establishments in urban areas have installed captive generation facilities. The term "captive" here refers to the fact that the power generating equipment so installed is used to meet only one's own electricity requirements. Captive generation in the residential sector is also not unknown.

Captive or non-utility generation may be divided broadly into three distinct economic categories: (i) Cogeneration, where process heat and electric power are produced simultaneously; (ii) Stand- by captive generation, which is used as a back-up in the event of a failure of utility power supply; and (iii) Pure captive generation, which is used to augment utility supply to meet power requirements. While cogeneration increases the overall efficiency of an industrial process and is desirable from the viewpoint of energy conservation, stand-by and pure captive generation is fossil- fuel based. It is not planned by the organized power supply sector, and is a result of decisions taken by individual electricity consumers -- in effect, it is a short term response to the power shortage situation.

The CEA compiles some information relating to non-utility generation systematically, but only from industrial units which have captive capacities of over 100 kW or a contract demand of at least 500 kVA. The most recent period for which such information is available, is 1985/86.

Non-utility generating capacity (as per data available from the CEA) has remained at about 10-11% of the total installed utility capacity in India since 1970/71. However, its average utilization rate has declined from over 3500 kWh/kW in 1970/71 to less than 2500 kWh/kW in 1985/86.

Although further details by type of industry and type of captive plant are available, the data obtained from the CEA have two major gaps: (i) there is no information on the use of small (mostly diesel based) captive generators in industrial establishments which have less than 100 kW of captive capacity; and (ii) there is no information on the monthly or seasonal variations in the use of captive generation facilities.

Table II.3.21

Captive generation and capacity (All India).

	Installed capacity (MW)	Energy generated (GWh)	Utilization factor
1984/85			
Steam	2803.181	9966.550	40.58
Diesel	2077.059	2001.180	10.99
Others	158.219	335.320	24.19
Total	**5038.059**	**12303.050**	**27.87**
1985/86			
Steam	2881.623	10226.83	40.51
Diesel	2378.392	2350.92	11.28
Others	159.119	419.60	30.10
Total	**5419.134**	**12997.35**	**27.38**
1986/87			
Steam	3328.695	10910.02	37.42
Diesel	2090.386	2258.28	12.33
Others	209.460	359.88	19.61
Total	**5628.541**	**13528.18**	**27.44**
1987/88			
Steam	3732.233	13737.16	42.02
Diesel	2277.766	2595.97	13.01
Others	246.112	522.31	24.23
Total	**6256.111**	**16855.44**	**30.76**
1988/89			
Steam	4534.7	16327.20	41.10
Diesel	2665.9	2703.55	11.58
Others	322.8	880.60	32.14
Total	**7523.4**	**19911.45**	**30.21**

Source: Central Electricity Authority, Public Electricity Supply, All India statistics General Review various issues.

Table II.3.22

Captive generation by industries.

Industry	No. of factories	Installed capacity (MW)	Energy generated (GWh)	Utilization factor (%)
1970/71				
a. Aluminium	7	147.8	1041.263	80.42
b. Chemicals	79	97.582	414.431	48.48
c. Fertilizers	14	87.407	444.870	58.10
d. Iron & steel	7	368.272	1252.635	38.83
e. Mineral oil and petroleum	9	81.601	316.429	44.26
f. Paper	28	89.605	383.860	48.90
g. Sugar	140	208.511	390.890	21.4
Total (a to g)	284	1080.778	4244.351	44.83
Total (All industries)	1086	1516.868	5247.239	40.24
1985/86				
a. Aluminium	8	288.5	2151.33	85.12
b. Chemicals	330	389.065	908.16	26.64
c. Fertilizers	35	343.743	1081.96	35.93
d. Iron & steel	21	623.4	2360.4	43.22
e. Mineral oil and petroleum	30	303.519	1098.07	41.30
f. Paper	121	285.5	837.85	33.50
g. Sugar	280	648.413	1066.05	18.77
Total (a to g)	**825**	**2882.14**	**9503.82**	**37.64**
Total (All industries)	**3648**	**5419.134**	**12997.35**	**27.38**
1986-87				
a. Aluminium	NA	NA	2552.08	NA
b. Cement	NA	NA	821.85	NA
c. Chemicals	NA	NA	1035.46	NA
d. Fertilizers	NA	NA	1154.42	NA

contd..

Table II.3.22 (contd.)

Captive generation by industries.

Industry	No. of factories	Installed capacity (MW)	Energy generated (GWh)	Utilization factor (%)
e. Iron & steel	NA	NA	2326.09	NA
f. Mineral oil and petroleum	NA	NA	1064.43	NA
g. Paper	NA	NA	1095.32	NA
h. Sugar	NA	NA	1016.84	NA
i. Textile	NA	NA	1366.27	NA
Total	**NA**	**NA**	**13528.18**	**NA**
1987/88				
a. Aluminium	NA	NA	4697.00	NA
b. Cement	NA	NA	1089.47	NA
c. Chemicals	NA	NA	1060.96	NA
d. Fertilizers	NA	NA	1515.88	NA
e. Iron & steel	NA	NA	2308.84	NA
f. Mineral oil and petroleum	NA	NA	1351.74	NA
g. Paper	NA	NA	871.99	NA
h. Sugar	NA	NA	1184.22	NA
i. Textile	NA	NA	1388.43	NA
Total	**NA**	**NA**	**16855.44**	**NA**
1988/89				
a. Aluminium	NA	NA	6235.00	NA
b. Cement	NA	NA	1095.00	NA
c. Chemicals	NA	NA	1350.00	NA
d. Fertilizers	NA	NA	1935.00	NA
e. Iron & steel	NA	NA	3035.00	NA
f. Mineral oil and petroleum	NA	NA	1370.00	NA
g. Paper	NA	NA	1030.00	NA
h. Sugar	NA	NA	1195.00	NA
i. Textile	NA	NA	1405.00	NA
Total	**NA**	**NA**	**18650.00**	**NA**

Source: Central Electricity Authority, Public Electricity Supply, All India Statistics, General Review, various issues.

Transmission and distribution network

The transmission and distribution sector faces several problems. Its expansion and strengthening has not kept pace with additions in generating capacity -- in certain instances, the utilization of generation capacity has been reduced simply because of poor reliability of the T/D network. This itself has aggravated power shortages in certain parts of the country. Furthermore, in the absence of regional or national integration of the T/D network, the power supplies cannot be optimized. Although the Rajyadhyaksha Committee (Government of India, 1980) had recommended that 50% of total power sector outlay should be earmarked for transmission/distribution facilities, actual investments during the Sixth and Seventh Five Year Plan periods have been about 38% only.

A high priority has been accorded only to the construction of high tension transmission lines of 400kV and 220kV. However, like for generation projects, there have been significant delays. During the period 1980/81 to 1988/89, the achievement in commissioning 400kV lines has been 18% short of target, and of 220kV lines, about 30% short.

During 1988/89, the progress in the transmission system expansion until February 1989 was: (i) completion of 2741 ckt-km of 400 kV lines and 2493 ckt-km of 220 kV lines; and (ii) commissioning of 2390 MVA of 400 kV substation, and 2730 MVA of 220 kV substations.

Transmission and distribution losses have also increased steadily during the last decade.

Table II.3.23

Transmission and distribution lines of utilities as on March 31 of each year (circuit kilometres).

	1980	1985	1986	1987	1988	1989
Northern region	**665188**	**931179**	**960374**	**1022766**	**1048633**	**1099016**
400 kV	762	2483	3632	3460	3470	3470
220/230 kV	8434	12279	13154	13528	13873	14509
132 kV	15222	20189	20513	21032	21279	21724
11/15 kV	250310	329655	332246	358662	369294	391391
Western region	**624377**	**879759**	**939544**	**1007081**	**1081423**	**1161855**
400 kV	690	2968	3456	4134	4938	5032
200/230 kV	9797	14417	14822	15115	16334	17001
132 kV	13871	17288	18111	18258	19409	19849
11/15 kV	176403	273592	286595	306478	326222	345374
Southern region	**797888**	**1039764**	**1097764**	**1148268**	**1235389**	**1303146**
400 kV	--	348	628	628	628	982
200/230 kV	8121	11867	12890	10334	10626	15934
132 kV	3599	5427	6307	6959	7405	7635
11/15 kV	182943	235088	246304	255194	270437	284648
Eastern region	**234700**	**293372**	**305580**	**320204**	**349356**	**398487**
400 kV	--	236	236	387	387	521
220/230 kV	3423	5402	6404	6621	6951	7149
132 kV	9514	13167	13337	13621	13302	13818
11/15 kV	96683	121281	125386	132625	145597	158399
North-eastern region	**29456**	**67782**	**67954**	**74141**	**77306**	**79578**
400 kV	--	--	--	--	--	--
220/230 kV	257	532	532	532	532	532
132 kV	13	2572	2765	2729	2728	2728
11/15 kV	10855	26799	27281	30862	31655	33084
All India	**2351609**	**3211956**	**3371216**	**3572460**	**3792107**	**4042022**
400 kV	1452	6035	7952	8609	9423	10005
220/230 kV	30032	44497	47802	49696	52206	55395
132 kV	43591	58643	61083	79422	81860	65754
11/15 kV	717194	986415	1030094	1091827	1151534	1221896

Source: Central Electricity Authority, Public Electricity Supply, All India statistics General Review various issues

Table II.3.24
Major transmission works (circuit kms).

Year	400 kV			220 kV		
	Target	Achievement	Short fall (%)	Target	Achievement	Short fall (%)
1980/81	415	223	46.3	5445	3476	36.2
1981/82	1535	244	84.3	5454	2499	54 2
1982/83	2010	1126	44.0	4971	3876	22.0
1983/84	1933	826	57.3	5305	1849	65 0
1984/85	1574	1500	4.7	3120	3565	9 7
1985/86	2428	2335	3 8	3598	2601	27 7
1986/87	2060	3400	65 0	2707	2003	26 0
1987/88	2694	1818	32 5	2730	2445	10 4
1988/89	2824	3134	11 0	3195	2998	6 2
1989/90	2850	2740	12 6	3220	3240	8 1
1990/91	3240	4725	45 8	3030	2489	17 9

Source. Current Energy Scene in India, July 1990, CMIE

Power losses

T/D losses in Indian utilities increased, on an average, from 17.5% in 1970/71 to 21.7% in 1985/86, and then levelled off to about 21.8% during 1986/87 and 1987/88. The most important reason for high T/D losses is the lack of adequate investment in T/D systems. For instance, a downward revision of the T/D outlay for the Seventh FYP period from Rs.220,000 million (as recommended by the Working Group on Power) to Rs.90,000 million, resulted in shelving all T/D system improvement schemes. This is despite the fact that a 1% reduction in overall T/D losses is estimated to be equivalent to an addition of 380 MW of generating capacity or energy generation at Rs.0.5/kWh (Advisory Board on Energy, "The Energy Scene". New Delhi, 1986).

In fact, it is believed that there is significant scope for reducing losses in the high tension part of the T/D system also. However, the concerned utilities need to conduct detailed analyses before establishing priorities for reducing technical losses in their T/D networks. Likewise, means of reducing pilferage must also be reviewed.

In addition to T/D losses, the conversion losses in thermal power stations (which now comprise a major share of generating capacity) are also considerably high. A comparison of average efficiencies of thermal units in various states reveals the rather substantial scope for reducing power generation intensity. However, it is important to

realize that this may be difficult to achieve as long as the thermal units are subject to frequent start-up and shut-down. Moreover, some of the older thermal units have boilers which are not designed to operate on high ash coals.

Table II.3.25
Energy generated and energy losses in utilities.
(GWh)

	1970/71	1979/80	1982/83	1985/86	1986/87	1987/88	1988/89	1989/90
Net energy generated	52964.4	98132.11	121234.33	157192.8	173390.18	185776.17	204032.93	
Energy losses(%)	17.5	20.4	21.1	21.7	21.5	22.1	21.8	23.0

Source: [1] Central Electricity Authority, Public Electricity Supply, All India Statistics General Review various issues.
[2] Current Energy Scene in India, July 1990, CMIE.

Table H.3.26

Transmission and distribution losses of SEBs*(%).

SEB/Department	T&D losses including unaccounted commercial losses				
	1985/86	1986/87	1987/88	1988/89	1989/90
Northern region					
Haryana	19.8	20.6	25.4	26.62	26.6
Himachal Pradesh	20.2	21.0	21.6	19.1	18.7
Jammu & Kashmir	35.9	33.5	41.8	41.0	49 5
Punjab	18.8	17.0	18 4	17.1	19.0
Rajasthan	26.5	23.9	21.0	23.7	22.0
Uttar Pradesh	20.5	20.0	26.8	26.5	26 1
Western region					
Gujarat	25.5	24 0	23 5	19 7	22 1
Madhya Pradesh	18 9	20 8	20 5	20 3	19 5
Maharashtra	14.5	14 5	14 3	14.4	17 6
Goa			24 6		
Daman & Diu	20 4	23 7	20.7	25 4	18 7
Southern region					
Andhra Pradesh	19 2	18 5	20.2	19 0	20 2
Karnataka	22.5	22 2	21.0	20 5	20 0
Kerala	24 6	27 5	21 3	25 7	22 0
Tamil Nadu	18 7	18 7	18 6	18 5	18 5
Lakshadweep	19 8	17 7	12 8	n a	n a
Eastern region					
Bihar	22 5	22 1	21 7	21 0	21 5
Orissa	23 0	22 0	23 3	24.8	24 0
Sikkim	18 2	19 6	23 9	23.1	23 4
West Bengal	23 1	23 2	21 2	23 4	21 6
North-eastern region					
Assam	20 0	21.0	20.2	21 3	21 6
Manipur	45 0	37 1	27.6	21 6	20 8
Meghalaya*	8 2	10 4	.8 4	9 6	10 9
Tripura	30 5	29 5	29.3	28 5	29 8
Mizoram	43 6	48 1	30.0	29 0	29.0
Arunachal Pradesh	30 4	35 0	31.3	23 5	27.6
All India (utilities)	21 7	21.5	21.5	21 8	23.0

*The lower T&D loss figure in respect of Meghalaya is due to bulk sale of energy at HT level to neighbouring states

Source. Current Energy Scene in India, July 1990, CMIE

Table II.3.27
State-wise efficiency of coal based steam thermal stations in 1985/86.

	Efficiency (%)	Energy input (goe/kwh)*
Northern region	**28.2**	**304.6**
Haryana	19.4	442.1
Jammu & Kashmir	13.3	647.5
Punjab	27.8	308.9
Rajasthan	29.7	289.5
Uttar Pradesh	24.4	353.0
Delhi	25.8	333.1
Central sector	31.7	270.8
Western region	**29.6**	**290.7**
Gujarat	28.6	300.2
Madhya Pradesh	28.6	300.2
Maharashtra	29 9	287.7
Central sector	33.9	253.4
Southern region	**29.60**	**290.0**
Andhra Pradesh	31.4	273 4
Tamil Nadu	31.0	277.4
Central sector	29.5	291.6
Eastern region	**25.20**	**341.3**
Bihar	22.4	384.6
Orissa	24.3	353.2
West Bengal	26.1	329.5
D.V.C.	26.0	331.0
Andaman & Nicobar	3.9	2191.7
North-eastern region	**23.10**	**371.8**
Assam	23.1	371.8

*1 goe = 1 gram of oil equivalent = 10 kCal

Source: Central Electricity Authority, Public Electricity Supply, All India statistics General Review, various issues

Integrated system operation

In order to promote the integrated operations of power systems, the country has been divided into five regions. To coordinate grid operations in the constituent states/union territories, as well as to ensure the optimal utilization of available generating capacity, a regional load despatch centre has been established in each of the regions.

At present, three RLDCs (of EREB, NREB and WREB) have computerized some of their operations. RLDCs of EREB (in Calcutta) and NREB (in New Delhi) have Siemens R30 systems; while WREBs RLDC (in Bombay) has PDP 11/70 and PDP 11/44 systems. The RLDC at Calcutta is connected to state/system load despatch centres (SLDCs) of DVC, BSEB, OSEB, WBSEB and CESC. The RLDC at New Delhi has data communication links with SLDCs of DESU, BBMB, RSEB and UPSEB; as well as with the Badarpur thermal power station. Similarly, the RLDC of WREB has data communication links with

the SLDCs of MPEB, GEB, MSEB and the Goa system. Several SLDCs also have computerized facilities, the most sophisticated being the SLDC of the MSEB system, which has Siemens R30 computers. In addition, in the Eastern Region, the SLDCs have Siemens R30 systems but with lesser facilities; and in the Western Region, GEB and MPEB have PDP 11/44 systems. The RLDCs and SLDCs are at present being used largely for system monitoring and report generation. Data acquisition systems have also been set up at various power stations, including the Central Sector power stations at Badarpur and Singrauli in the north, Farakka in the east, Ramagundam in the south, and Korba in the west.

The present limited use of the already available sophisticated computer and software facilities in RLDCs will be expanded following the establishment of full-fledged SCADA facilities at SLDCs, and suitable data communication links. The long term objective is to have basically a three level hierarchical system control structure: a National Load Despatch Centre (NLDC); five RLDCs; and several SLDCs. In addition, depending on the system size, a SLDC may have two or three sub-state/system load despatch centres (SSLDCs) or data concentrator stations as subordinates. Central Sector power stations will be controlled from Central Project Control Centres (CPCCs) which will also be subordinate to the respective RLDCs. The responsibilities of the various load despatch centres will be much in line with what may be expected in a hierarchical control structure; as described below.

The proposal is to first develop a National System Information Centre, which will later be upgraded to a full load despatch centre (the NLDC). Major functions of the NLDC would be: (i) to monitor the operation of the all India grid (i.e. the 400 kV network, d.c. links and other inter-regional connections); (ii) to provide generation or transfer guidelines to the RLDCs up to a few hours or even some days in advance; (iii) to coordinate the re-establishment of inter-Regional grid interconnections in the event of major disturbances; and (iv) to coordinate maintenance outages as well as generation (through RLDCs).

The RLDCs will in due course, become the overall coordinators of power activities within their respective regions. Their functions will comprise data logging, automatic generation control through real time economic load despatch, generation scheduling, preparation of merit order for scheduling and despatch of generation, allocation of spinning reserve within the region, monitoring and maintenance scheduling for generating units of more than 50 MW size and for the 400kV and 220kV network, accounting for energy exchanges and consumption by the states within the region and for inter- regional exchanges, supervisory control of switching operations on inter-state/regional and Central Sector project transmission lines, coordination of reactive power management of SLDCs, disturbance analysis, and preparation of operating procedures under emergency conditions. The RLDCs will thus coordinate their work with the NLDC.

The SLDCs in turn, will coordinate with the concerned RLDC, the various power

sector activities within their system/state. To assist the RLDCs in operational planning, the SLDCs will provide information on weather forecast, expected state demand and generation capability for the following day, merit order of loading generating plant, analysis of system disturbances, maintenance schedules (for approval by RLDC) for state owned plant (units above 50 MW) as well as 400 kV and 220 kV lines which form a part of the main interconnected system, and so forth. The real-time control facilities of SLDCs will include economic load despatch within the state/system, supervisory control of power plant and implementation of switching instructions from the RLDC, reactive power control, state estimation and security evaluation of 400 kV, 220 kV, 132 kV and 110 kV systems, and to implement operating procedures under emergency conditions.

Furthermore, the SLDCs will operate taking into account information flows from the SSLDCs and data concentrator stations. Data acquisition systems (DAS) will also be installed at power stations, to feed data on to SSLDCs and concentrator stations. In fact, some major power stations have already been equipped with DAS facilities.

Electricity utilization

With the growth in the T/D network, there has been a rapid increase in the number of towns and villages electrified. While all urban areas are now electrified, a 100% rural electrification has been achieved only in a few states, such as Punjab, Haryana and Tamil Nadu. With an increase in rural electrification, there has been a steep increase in the number of pumpsets energized. This has certainly helped in raising agricultural productivity, but the power supply situation in urban areas has suffered. It is important to note that the power supply situation in urban areas has deteriorated even though relatively few rural households have obtained electricity connections.

Although both the number of consumers and the sanctioned/connected load have increased rather rapidly, the data base cannot be taken as indicative of future trends. This is because of long lead times in obtaining connections; as well as the fact that the actual connected load may often exceed the sanctioned load significantly.

Table II.3.28

Number of towns electrified in various population groups - as on march 31 of each year.

Population	1971[a]	1974[a]	1977[b]	1980[b]	1983[b]	1987[b]	1989[b]
< 5000	266	267	294	296	296	297	297
5000- 9999	844	846	820	820	820	820	820
10000-19999	819	819	987	987	987	987	987
20000-49999	518	518	652	652	652	652	652
50000-99999	139	139	219	219	219	219	219
> = 100000	107	107	151	151	151	151	151
Total	**2693**	**2696**	**3123**	**3125**	**3125**	**3126**	**3126**

[a] Towns in population groups as per 1961 census.

[b] Towns in population groups as per 1971 census.

Source: Central Electricity Authority, Public Electricity Supply, All India statistics General Review various issues.

Table II.3.29

Number of villages electrified in various population groups

As on March 31st of each year.

Population group	1971[a]	1980[b]	1983[b]	1986[b]	1988[c]	1989[c]	1990[c]	1991[c]
< 500	31824	95253	140092	178680	197304	208713	N.A.	N.A.
500 - 999	26668	67650	86596	104545	112551	117527	N.A.	N.A.
1000 - 1999	25887	53381	61864	69536	78523	80658	N.A.	N.A.
2000 - 4999	17168	27938	29677	31784	39248	40345	N.A.	N.A.
5000 - 9999	2688	4283	4355	4428	6304	6478	N.A.	N.A.
> = 10000	704	1294	1297	1320	1723	1770	N.A.	N.A.
Total	**104939**	**249799**	**323881**	**390293**	**435653**	**455491**	**470580**	**478966**

[a] Villages in population groups as per 1961 census.

[b] Villages in population groups as per 1961 census.

[c] Villages in population groups as per 1981 census.

Sources: [1] statistics General Review various issues.

[2] Current Energy Scene in India, July 1990, CMIE.

Table II.3.30

Number of consumers and connected load as on March 31 of each year.

	1971	1980	1985	1987	1988	1989
Domestic						
No. of consumers('000)	10165.2	20375.1	30723.9	37192.6	39583.7	43482.8
Connected load (MW)	5985.9	11716.1	18922.7	22638.7	24751.6	26941.8
Commercial						
No. of consumers('000)	2305.7	4277.3	5882.7	6473.5	6779.9	7302.8
Connected load (MW)	1911.0	4194.4	5820.1	6336.6	6854.0	7140.1
Industrial (LV & MV)						
No. of consumers('000)	532.3	051.2	1508.3	1689.9	1779.1	1898.6
Connected load (MW)	4560.6	9019.9	15473.7	18062.3	17282.9	18408.4
Industrial (HV)						
No. of consumers('000)	10.0	22.2	20.2	21.9	25.3	28.0
Connected load (MW)	6383.6	13600.9	15865.9	17047,2	20166.6	20608.5
Public lighting						
No. of consumers('000)	58.3	129.3	180.9	210.9	255.7	270.9
Connected load (MW)	167.7	305.5	434.2	508.2	535.5	565.6
Traction						
No of consumers('000)	69.0	60.0	110.0	111.0	123.0	135.0
Connected load (MW)	417 7	783.4	991.0	1048 2	1125.8	1219 5
Agriculture						
No. of consumers('000)	1570.9	3880.5	5588.5	6484.8	6992.9	7638.7
Nonnected load (MW)	6224.8	15247 4	21255.2	24286.9	26105.0	28466.1
Public water works sewage						
No. of consumers('000)	10.2	35.5	64.5	87.0	97.5	105.8
Connected load (MW)	269.7	650.8	1077.0	1180 0	1252 8	1495.1
Miscellaneous						
No of consumers('000)	12.2	57 2	666.6	156.4	93.9	97.6
Load (MW)	309.0	605.2	1394.0	1136.5	858.1	1110.7
Total						
No of consumers('000)	14665.0	29828.2	44636.0	52317.2	55607.4	60824.7
Connected load (MW)	26230 2	56123 4	81234 3	92244.6	98932.8	105955.7

Source· Central Electricity Authority, Public Electricity Supply, All India Statistics General Review various issues.

Table II.3.31

Trends in village electrification and pumpset energisation.

	Villages electrified		
Year	**Number**	**As a % of total no. of villages**	**Pumpsets energised ('000)**
1950/51	3,061	0.5	21
1955/56	7,294	1.3	56
1960/61	21,754	3.8	199
1965/66	45,148	7.8	513
1968/69	73,739	12.8	1089
1973/74	1,56,729	27.2	2426
1977/78	2,16,863	37.6	3300
1978/79	2,32,770	40.4	3599
1979/80	2,49,799	43.4	3966
1980/81	2,72,625	47.3	4330
1981/82	2,96,511	51.5	4659
1982/83	3,23,881	56.2	4973
1983/84	3,47,561	60.3	5309
1984/85	3,70,332	64.3	5709
1985/86	3,90,294	67.7	6152
1986/87	4,02,647	69.9	6479
1987/88	4,35,653	75.2	7226
1988/89	4,55,491	78.7	7819
1989/90	4,70,580	81.3	8350

Sources: [1] Current Energy Scene in India, July 1990, CMIE.
[2] Annual Report 1990-91, Ministry of Energy, Deptt. of Power, GOI.

Table II.3.32

Peak demand.

	Month in which demand was max.	Actual peak demand *(MW)
1980/81		
Northern	January	5015
Western	January	5442
Southern	November	4425
Eastern	February	2429
North-eastern	March	189
All India **	---	17500
1984/85		
Northern	December	6366
Western	March	7719
Southern	December	6596
Eastern	March	3001
North-eastern	October	338
All India **	---	24020
1985/86		
Northern	February	7238
Western	March	8537
Southern	February	6978
Eastern	November	3132
North-eastern	November	363
All India **	---	26248
1986/87		
Northern	March	8734
Western	March	9490
Southern	February	8190
Eastern	March	3657
North-eastern	February	419
All India **	---	30490

contd...

Table II.3.32 (contd.)
Peak demand.

	Month in which demand was max.	Actual peak demand *(MW)
1987/88		
Northern	November	9210
Western	February	9855
Southern	February	8134
Eastern	October	3681
North-eastern	December	434
All India **	---	31314
1988/89		
Northern	February	9541
Western	February	10933
Southern	December	8932
Eastern	March	3816
North-eastern	January	506
All India **	---	33728

* Figures for peak demand are of actual simultaneous peak demand on the regional system, irrespective of power restrictions.
** Non coincident aggregate.
Sources: [1] Central Electricity Authority, Public Electricity Supply, All India Statistics General Review various issues.
[2] CEA,Thirteenth Electric Power Survey of India, New Delhi, May 1988.

Finances of the power sector

The power supply industry is highly capital intensive and dearth for funds imposes serious constraints on setting up power projects commensurate with growing requirements. Even though primary reliance is on plan resources and indigenous sources of finances for power development, there is a large gap between requirement of funds for the necessary additions to the existing capacity and what can be provided by the Government through normal process of plan outlays.In view of this, external assistance is resorted to, for selected power projects, in order to meet the requirements of new projects.The external assistance is received in the form of grants, soft loans, mixed financing terms and export credits on commercial terms.[CMIE, CES, 1990]. Some financial statistics are given for the SEBs in tables II.3.33 through II.3.35.

Table II.3.33

Net commercial loss (-)/profit (+) of SEBs. (Rs.million)

	Net commercial loss/profit during the year				Cumulative loss/profit as on March-end 1990
	1986-87	1987-88	1988-89	1989-90	
Andhra Pradesh	90	293	471	579	2340
Assam	-513	-172	-1199	-871	-5469
Bihar	42	-257	-484	-83	-3285
Gujarat	134	243	-1403	-2399	-3363
Haryana	-612	-809	-521	-568	-6251
Himachal Pradesh	-408	-166	-149	-134	-1870
Karnataka	-745	-1045	-464	-172	-1337
Kerala	-53	68	-371	-237	-550
Madhya Pradesh	944	644	800	826	3356
Maharashtra	644	732	395	203	1866
Meghalaya	-05	24	15	11	-240
Orissa	-38	-455	-30	271	-989
Punjab	-198	-50	-586	-934	-2792
Rajasthan	-242	-659	-295	-1173	-4441
Tamil Nadu	-	332	413	1554	3482
Uttar Pradesh	540	666	-2318	-2044	-10241
West Bengal	-82	-267	-255	-88	-2864
Total losses	**-2896**	**-3880**	**-8075**	**-8708**	**-43692**
Total profits	**2394**	**3002**	**2094**	**3444**	**11044**

Source: CMIE, Current Energy Scene in India, 1990.

Table II.3.34
Financial statements of SEBs

	FISCAL YEARS								
	1980	1983	1984	1985	1986	1987	1988	1989	1990
Andhra Pradesh									
Total investment in power sector (million Rs.)		1735.30	1350.00	2000.00	1700.00	1800 00	2057.30	2350 0	
Operating ratio	0 77	0 83	0.76	0.31	0 31	0 82	0 85	0 88	
Debt-service ratio									
Self financing ratio(%)	22 68	23 17	30 78	-	-	0 00	13 20	11 94	
Rate of return(%)	-	1 26	5.40	1 39	-	2 51	1 31	0 18	
Assam									
Total investment in power sector (million Rs)		907 00	1083 50	1080 50	1222 70	1230 70	1300 00	1485 60	
Operating ratio	1 22	1 12	1 24	1 21	1 70	1 22	1 34	1 45	1 45
Debt-service ratio	0 68	0 35	0 27	0 31	0 26	0 00	-0 09	-0 18	-0 15
Self financing ratio(%)	-1.98	-7 01	-6 92	-11 91	-58.42	-41 23	-41 81	-43 94	-41 09
Rate of return(%)	-	-49 66	-58 49	-82 71	-183.12	-38 71	-38 77	-41 92	-43 15
Bihar									
Total investment in power sector (million Rs)		1557 30	1555 00	1696 00	1580 00	2350 00	3295 00	4500 00	
Operating ratio	1 22	1 17	1 18	1 36	1 38	1 39	1 41		
Debt-service ratio	0 46	0 97	0 79	-0 01	0 06	-0 11	-0 23		
Self financing ratio(%)	-5 39	1 74	2 38	-24 29	-14 97	-28 57	-30 47		
Rate of return(%)	-	-2 95	-2 06	-19 00	0 54	-2 52	-16 81		
Gujarat									
Total investment in power sector (million Rs)		2090 00	2650 00	2600 00	1915 70	2477 50	3067 00	3684 10	
Operating ratio	0 89	0 77	0 82	1 04	0 97	1 03	1 08	1 08	1 02
Debt-service ratio	1 51	3 33	3 17	4 12	3 80	3 74	0 61	0 09	0 98

contd

Table II.3.34 (contd.)
Financial statements of SEBs.

	FISCAL YEARS								
	1980	1983	1984	1985	1986	1987	1988	1989	1990
Self financing ratio(%)	11.90	48.11	45.23	44.57	49.53	54.16	-5.32	-19.57	22.68
Rate of return(%)	-	1.97	4 19	-0.17	1.27	1.90	0.95	-12.64	3.0
Haryana									
Total investment in power sector (million Rs.)		1025.00	1351.50	1379 70	1330.00	1626.90	1950.40	2020.00	
Operating ratio		0.96	1.00	0 88	1.14	1.60	1.13	1.43	1.30
Debt-service ratio	0.40	0.48	0.19	0.61	0.30	-0.41	0.17	-0.17	-0.06
Self financing ratio(%)	-10.26	-4.38	-13 01	0.44	-4.64	-65.90	1.92	-16.43	-18.35
Rate of return(%)	-	-7.65	-13 08	-2 15	-9 79	-21 62	-5.83	-15.32	-16.38
Karnataka									
Total investment in power sector (million Rs)		1418.10	1740 60	1591 10	1472.40	1748.70	2107.50	2960 50	
Operating ratio	0.77	0.85	0.83	0.96	1.09	1.06	0.94	0.98	0.98
Debt-service ratio									
Self financing ratio(%)	25 88	18.58	16.62	24 77	-13.35	-21.06	8.68	-3.31	-0.69
Rate of return(%)		4.22	3 06	-6 80	-17.22	-21.65	-9 28	-14.06	-13.00
Kerala									
Total investment in power sector (million Rs)		500 00	625 00	675 00	633.00	769.00	890.00	1140.00	
Operating ratio	0.64	0 68	0 63	0.78	0.78	0.92	0.91	0.89	0.97
Debt-service ratio	1.71	1 01	1.52	0.85	0 72	0 47	0.73	0.72	0.34
Self financing ratio(%)	19 42	5 97	11.13	8 19	-0.29	-6.54	4.78	5.59	-2 52
Rate of return(%)		-3.60	2.96	0.10	-1 62	-16.52	-4.39	-2.76	-10.65

contd...

Table II.3.34 (contd.)
Financial statements of SEBs.

	FISCAL YEARS								
	1980	1983	1984	1985	1986	1987	1988	1989	1990
Madhya Pradesh									
Total investment in power sector (million Rs.)		3154 50	2982.50	3365.10	3327 60	3345 00	4076.70	6907 50	
Operating ratio	0.84	0.79	0.82	0.80	0 79	0 84	0 96	0 86	0 87
Debt-service ratio	0 98	1 10	1.01	1 25	1 12	1 16	0 97	0 92	1 02
Self financing ratio(%)	1 20	5 88	7.00	19 70	17 00	17 32	10 47	18 72	26 07
Rate of return(%)		-0 18	-1 60	4 34	5 94	2 98	-0 59	0 61	0 53
Maharashtra									
Total investment in power sector (million Rs)		4440 00	4492 00	4503 40	4048 30	4726 00	5051 60	5513 10	
Operating ratio	0 95	0 87	0 92	0 98	0 83	0 91	1 00	1 03	0 84
Debt-service ratio	0 99	1 09	1 08	1 65	1 36	1 37	1 11	1 08	0 93
Self financing ratio(%)	2 95	5 32	5 84	14 58	18 66	18 29	13 13	11 29	14 33
Rate of return(%)	-	-1 90	-2 10	2 82	3 90	2 87	1 41	0 48	1 91
Orissa									
Total investment in power sector (million Rs)		840.00	912 00	957 40	1143 11	1544 60	1847 20	2611 40	
Operating ratio	0 59	0.62	0 74	0 88	0 92	1 16	1 14	0 85	0 73
Debt-service ratio	1 38	0 95	0 83	0 76	0.86	0 24	0 66	0 54	0 61
Self financing ratio(%)	16 51	24 84	23 00	27 10	45 10	-23 46	39 32	25 00	107 94
Rate of return(%)		-0 20	-2 99	-2 35	-0 86	-9 73	-4 93	3 41	6 62
Punjab									
Total investment in power sector (million Rs.)		234 11	257 22	197 91	270 11	415 30	452 08	317 52	
Operating ratio	**0.98**	**0.91**	**1.01**	**1.05**	**1.14**	**1.24**	**1.31**	**1.38**	1 15
Debt-service ratio	1 41	1 13	0 91	0 41	1 58	0 56	0 53	0 54	

contd

Table II.3.34 (contd.)
Financial statements of SEBs.

	FISCAL YEARS								
	1980	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Self financing ratio(%)	19.89	7.77	13.17	-7.76	8.55	4.34	3.01	3.31	14.24
Rate of return(%)		-1.99	-0.70	-0.48	-1.26	-0.31	-3.57	-2.48	3.00
Rajasthan									
Total investment in power sector (million Rs.)		1150.00	1220.00	1150.80	1226.90	2890.00	2200.00	2140.00	
Operating ratio	1.02	0.94	1.06	1.01	0.91	1.09	1.02	1.00	1.07
Debt-service ratio	1.13	0.56	0.35	0.53	0.83	0.59	0.71	0.56	0.23
Self financing ratio(%)	8.06	-4.59	-10.38	-0 64	8.45	-2.21	4.80	-10.66	-23.40
Rate of return(%)	-	-6.56	-8 63	-5.04	-2.47	-6.04	-4.80	-7.78	-10.61
Tamil Nadu									
Total investment in power sector (million Rs.)		2062.50	1691.60	2412.30	3358.20	3933.60	4076.40	3850.00	
Operating ratio	1.23	1.26	1.10	1.19	1.16	1.24	1.32	1.31	
Debt-service ratio	1 83	1.35	1 55	2 62	1.42	1.07			
Self financing ratio(%)	18.46	8.94	12.32	16.74	13.21	9.64	0.00		
Rate of return(%)	-	-1.40	1.00	2.89	1.00	5.76	3.00		
Uttar Pradesh									
Total investment in power sector (million Rs)		3887.90	4854.40	5800 00	5948.60	6901.70	8567.80	8700.50	
Operating ratio	**1.04**	**1.01**	**1.01**	**1.18**	**1.00**	**1.15**	**1.23**	**1.19**	
Debt-service ratio	1.06	0.97	1.26	0 28	0.64	1.23			
Self financing ratio(%)	5.20	3.54	3.79	-11.87	-1.52	-7.62	0.00	0.00	
Rate of return(%)		-2.02	-2.52	-6.04	2.89	1.82	0.04	1.11	
West Bengal									
Total investment in power sector (million Rs.)		1638.50	1410.10	1160.00	1647.00	2055.60	2404.00	3860.00	

contd...

Table II.3.34 (contd.)
Financial statements of SEBs.

	FISCAL YEARS								
	1980	1983	1984	1985	1986	1987	1988	1989	1990
Operating ratio	0.95	1.00	1.03	1.05	1.00	1.09	1.09	1.05	1 31
Debt-service ratio	0.85	0.42	0.55	0.44	0.54	0.37	0.36	0.33	-0 23
Self financing ratio(%)	0.53	-6.95	-0.35	-0.09	4.47	2.27	1 71	1.89	-13 74
Rate of return(%)		-18.32	-8.95	-7.85	-2.34	-8.20	-8.95	-10.24	-36.68

Source: TERI data file.

Table II.3.35
Average cost of generation & supply and Average rate of realisation in major states: 1988-1989.

	Average cost of generation and supply	Average rate of realisation		
		Domestic	Agriculture	Industry
Andhra Pradesh	61.44	56.67	4.50	108.12
Bihar	131.90	63.33	9.41	131.02
Gujarat	105.40	66.56	20.82	116.25
Haryana	88.36	59.00	28.01	115.36
Himachal Pradesh	117.28	45.50	20.00	70.59
Karnataka	77.74	64.50	11.55	100.50
Kerala	61.29	47.66	22.04	48.47
Madhya Pradesh	81.64	49.00	24.61	101.332
Maharashtra	91.11	43.50[@]	9.00	112.54
Orissa	72.43	89.33	22.05	62.47
Punjab	84.45	60.33	9.18	62.84
Rajasthan	88.50	58.22[a]		90.99
Tamil nadu	90.01	56.67	11.20	88.36
Uttar Pradesh	101.34	75.00	22.67	108.16
West Bengal		5	26.86	91.06
Assam	244.76	65.00	30.00	82.76
Meghalaya		5	22.06	54.84
Total	**91.04**	**53.93***	**15.70**	**97.85**
consumption of power *(%) during 1988-89*	·	15	24	48

* Without State Electricity Duty

[@] For Bombay and Pune, 42.50 for other areas

[a] Relates to 1987-1988.

Source: CMIE, Current Energy Scene in India, 1990.

Biomass

Introduction

Biomass comprises all forms of matter derived from biological activities, and is present either on the soil surface, or at various depths of the vast body of water-lakes, streams, rivers, seas and oceans. However, the biomass of immediate concern is that growing above ground. Biomass, though abundant in India, is a scattered resource. With an increase in agricultural productivity, human and livestock population, and urbanization and industrial output, the production of waste materials (that may be used as a source of energy) has increased. The data base in this area is however, very deficient. The data available are usually "normative" rather than actual -- although the norms themselves may be derived from some isolated sample surveys.

There is therefore a need to assess the availability of residues, their method of collection and storage, their chemical composition, calorific content and other characteristics, environmental implications of their utilization, and so forth. Only with such an overall assessment will it be possible to formulate an appropriate policy for biomass utilization.

The availability of biomass is related to the land utilization pattern. Some aggregate land utilization data are presented below.

Table II.4.1

Land utilization (1987/88).

	Area (mha)	% of the total geographical area
a. Total geographical area	328.7	100.0
b. Area under forest	66.9	20.3
c. Area not available for cultivation	41.2	12.5
c1 Barren and unculturable lands	20.4	6.2
c2 Land put to non-agricultural uses	20.8	6.3
d. Other uncultivated land (excluding current fallow)	31.0	9.5
d1 Permanent pastures and other grazing lands	11.9	3.6

contd...

Table II.4.1 (contd.)
Land utilization (1987/88).

	Area (mha)	% of the total geographical area
d2 Land under miscellaneous tree crops and groves not included in net area sown	3.5	1.1
d3 Culturable wastelands	15.6	4.8
e. Fallow lands	29.6	9.0
e1 Current fallow	18.5	5.6
e2 Fallows other than current	11.1	3.4
f. Area under agriculture (net sown area)	136.2	41.4

b. Includes all lands classified as forests under any legal enactment dealing with forests or administered as forests, whether state-owned or private, and whether wooded or maintained as potential forest land.

c1. Includes mountains, deserts etc. Land which cannot be brought under cultivation unless at a high cost are classified as unculturable, whether such land is in isolated blocks or within cultivated holdings.

c2. Includes all land occupied by buildings, roads and railways or under water (e.g. rivers, canals, lakes etc.), as well as other land put to uses other than agriculture.

d. Includes: (i) permanent pastures and other grazing lands; (ii) all cultivated land not included in net sown area, but used for planting miscellaneous crops (casuarina, thatching grass, bamboo bushes) and groves for fuel etc. which are not classified as orchards; and
(iii) land cultivated earlier but not for at least five years in succession.

e. Includes land kept fallow in the current year but not for more than five years in succession.

f. Area sown with crops and orchards, counting areas sown more than once in the same year only once.

Source : Directorate of Economics & Statistics, Ministry of Agriculture, GOI.

Forestry

According to the National Forest Policy (1988), 33% of the total land area, or around 100 million hectares (mha) of land should be under forest cover. However, the forest cover is still much less; the forests are scattered and several parts of the country have no forests at all.

According to one set of estimates, about 4.5 mha of forest area were clear-felled between 1947 and 1967. This represents an average annual loss of about 150,000 hectares. However, these figures may represent only the authorized encroachment of land for extending agriculture, and for establishing industries and other development projects. A large portion of forest area is being denuded also because of excessive use, resulting in loss of productivity. It is estimated that over 5 mha of forest area is under shifting cultivation, and the capacity of these lands for producing forestry goods and services is severely limited. It is for such reasons that the Government has undertaken a large programme of afforestation, social forestry and farm forestry.

Table II.4.2

Classification of total recorded forest area*

('000 sq km)

Year	Total forest area	By composition		By types coniferous	
		Coniferous	Non-coniferous	Merchantable	Unprofitable or inaccessible
1951/52	734.4	34	700.4	554.9	179.5
1955/56	703.6	25.2	678.4	564.9	138.7
1960/61	689.5	44.3	645.2	529.4	160.1
1965/66	751.9[a]	46.7	699.0	594.1	151.6
1970/71	747.7[a]	39.2	699.2	577.4	161.0
1975/76	747.3[b]	47.4	634.1	585.7	161.6
1976/77[p]	750.4[b]	40.5	692.1	565.9	173.9
1977/78[p]	747.6[b]	39.9	689.4	565.8	170.8
1978/79[p]	747.4[b]	47.7	681.3	565.9	170.4
1979/80[p]	736.6[b]	47.6	670.3	564.9	160.4
1985/86	642.0	NA	NA	NA	NA

* Area under forest departments.

[p] Provisional.

[a] Includes 6212 sq km in 1965-66 and 8566 sq km in 1970-71 for want of legal classification.

[b] Also includes forest area which is not accounted for due to want of details.

Sources: [1] Central Statistical Organisation (CSO), Statistical Abstract, GOI, New Delhi, 1987; and

[2].Department of Environment and Forests.

Table II.4.3

Statewise actual forest cover (1985-87 imagery).

State/UTs	Actual forest Area in (Sq.km)	Cover (Sq.km)
Andhra Pradesh	63771	47911
Arunachal Pradesh	51540	68763
Assam	30708	26058
Bihar	29230	26934
Goa (including Daman & Diu)	1053	1302
Gujarat	18777	11670
Haryana	1685	563
Himachal Pradesh	21325	1337
Jammu & Kashmir	20892	20424
Karnataka	38644	32100
Kerala	11222	10149
Madhya Pradesh	155414	133191
Maharashtra	64055	44058
Manipur	15155	17885
Meghalaya	8514	15690
Mizoram	15935	18178
Nagaland	8625	14356
Orissa	59555	47137
Punjab	2803	1161
Rajasthan	31151	12966
Sikkim	2650	3124
Tamilnadu	22319	17715
Triupura	6280	5325
Uttar Pradesh	51269	33844
West Bengal	11879	8394
Andaman & Nicobar Island	7144	7624
Chandigarh	6	8
Dadra & Nagar haveli	203	205
Delhi	42	22
Total	**757846**	**640134**

Source: The State of India's Forests Report, 1989, Forest Survey of India, GOI, Dehradun.

Table II.4.4

Total forest area by type of legal status*.

('000 sq km)

Year	Reserved	Protected	Unclassed
1951/52	344.8	152.0	237.5
1955/56	359.4	168.5	170.2
1960/61	316.1	240.5	112.1
1965/66	348.4	249.3	127.7
1970/71	360.2	212.7	115.1
1975/76	389.7	231.9	125.8
1976/77[p]	363.9	236.6	119.0
1977/78[p]	367.6	236.3	112.4
1978/79[p]	373.6	232.9	107.9
1979/80[p]	372.5	225.3	105.6
1985/86	406.1	215.0	131.0

* Area under forest departments.

p Provisional.

Sources: [1] Central Statistical Organisation (CSO), Statistical Abstract, GOI, New Delhi, 1987; and [2] Department of Environment and Forests.

Table II.4.5

Actual forest cover by density classes (1989).

(Area in Sq.Km.)

State/UTs	Dense forest (Crown density above 40%)	Open forest (Crown density 10% to 40%)	Actual forest cover (Sq.km.)
Andhra Pradesh	25535	21971	47911
Arunachal Pradesh	54272	14491	68763
Assam	15688	9370	26058
Bihar	13412	13522	26934
Goa (including Daman & Diu)	975	322	1302
Gujarat	5259	5999	11670
Haryana	130	433	563
Himachal Pradesh	7100	6277	1337
Jammu & Kashmir	10824	9600	20424
Karnataka	24749	7351	32100
Kerala	8312	1837	10149
Madhya Pradesh	91448	41743	133191
Maharashtra	26177	17767	44058
Manipur	5060	12825	17885
Meghalaya	3427	12263	15690
Mizoram	3883	14295	18178
Nagaland	4632	9724	14356
Orissa	27561	19384	47137
Punjab	97	1064	1161
Rajasthan	2902	10064	12966
Sikkim	2410	714	3124
Tamil Nadu	9759	7909	17715
Tripura	1214	4111	5325
Uttar Pradesh	22632	11212	33844
West Bengal	3332	2953	8394
Andaman & Nicobar Islands	6518	133	7624
Chandigarh	-	8	8

contd...

Table II.4.5(contd.)

Actual forest cover by density classes (1989).

(Area in Sq.Km.)

State/UTs	Dense forest (Crown density above 40%)	Open forest (Crown density 10% to 40%)	Actual forest cover (Sq.km.)
Dadra & Nagar haveli	149	56	205
Delhi	12	10	22
Total	**378470**	**257409**	**640134**

Source: The State of India's Forests Report, 1989, Forest Survey of India, GOI, Dehradun.

Table II.4.6

National parks and sanctuaries.

Region	No. of National parks	No. of Sanctuaries	Area covered by N. Parks (mha)	Area covered by Sanctuaries (mha)	Total area covered by N.parks & Sanctuaries	% of total area to Geographical forest area	% of total area to Recorded area
Northern	14	94	0.95	2.41	3.36	3.32	26.01
Western	21	74	0.75	4.11	4.86	5.11	20.29
Southern	11	59	0.31	1.88	2.19	3.44	16.10
Eastern	12	143	0.33	1.12	1.45	3.40	13.45
Northeastern	9	28	0.44	0.37	0.81	3.09	5.81
All India	**67**	**398**	**2.78**	**9.89**	**12.67**	**3.85**	**16.85**

Source : The State of India's Forests Report, 1989, Forest Survey of India, GOI, Dehradun.

Table II. 4.7.
World forest resources.

Countries	Forest area (mha)	Percent land under forest	Per capita forest (ha)	Annual deforestation (th.ha)	Rate of afforestation (th. ha)
Asia					
India	77.9	26.2	0.1	147	120
Pakistan	4.1	5.3	0.04	7	7
Bangladesh	2 2	16.4	0 02	8	9
China	170	18.2	0 16	n a	4552
Japan	25.3	68.4	0.21	n.a.	240
Indonesia	126.2	69.7	0.76	600	187
Oceania					
Australia	106 8	14	6 7	n a	62
North America					
U.S A	298	32 7	1 25	n a	1775
Canada	436	47 3	17	n a	720
Europe					
Denmark	0 5	11 7	0 1	n a	n a
Sweden	27 8	637.5	3 36	n a	207
France	15 1	27 7	28	n a	51
W Germany	7.2	29 5	0 12	n a	62
U.K.	2.2	9.1	0 04	n a	40
S. America					
Brazil	553	65 4	4 08	1480	346
World	**4289**	**32.8**	**0.89**		
Developed	**1968**	**35.9**	**1.63**		
Developing	**2321**	**30.6**	**0.64**		

n a not available

Source FAO, Yearbook of Forest Products - 1985

Table II. 4.8

Estimates of wastelands in India.

(mha)

State/UT	**Non-forest degraded area**	**Forest* degraded area**	**Total**
Andhra Pradesh	7.682	3.734	11.416
Assam	0.935	0.795	1.73
Bihar	3.896	1.562	5.458
Gujarat	7.153	0.683	7.836
Haryana	2.404	0.074	2.478
Himachal Pradesh	1.424	0.534	1.958
Jammu and Kashmir	0.531	1.034	1.565
Karnataka	7.122	2.043	9.165
Kerala	1.053	0.226	1.279
Madhya Pradesh	12.947	7.195	20.142
Maharashtra	11.56	2.841	14.401
Manipur	0.014	1.424	1.438
Meghalaya	0.815	1.103	1.918
Nagaland	0.508	0.878	1.386
Orissa	3.157	3.227	6.384
Punjab	1.151	0.079	1.23
Rajasthan	18.001	1.933	19.934
Sikkim	0.131	0.15	0.281
Tamil Nadu	3.392	1.009	4.401
Tripura	0.108	0.865	0.973
Uttar Pradesh	6.635	1.426	8.061
West Bengal	2.177	0.359	2.536
UTs	0.889	2.715	3.604
All India	**93.691**	**35.889**	**129.58**

* Barren area notified as forest not included in the above figures.

Source : Society for Promotion of Wastelands Development, New Delhi. 1984

Table II. 4.9

Estimates of wastelands in India.

(mha)

State/UTs	Saline & alkaline lands	Wind eroded area	Water eroded area	Total
Andhra Pradesh	0.24	-	7.442	7.682
Assam	-	-	0.935	0.935
Bihar	0.004	-	3.892	3.896
Gujarat	1.214	0.704	5.235	7.153
Haryana	0.526	1.599	0.276	2.404
Himachal Pradesh	-	-	1.424	1.424
Jammu and Kashmir	-	-	0.531	0.531
Karnataka	0.404	-	6.718	7.122
Kerala	0.016	-	1.037	1.053
Madhya Pradesh	0.242	-	12.705	12.947
Maharashtra	0.534	-	11.026	11.56
Manipur	-	-	0.014	0.014
Meghalaya	-	-	0.815	0.815
Nagaland	-	-	0.508	0.508
Orissa	0.404	-	2.753	3.157
Punjab	0.688	-	0.463	1.151
Rajasthan	0.728	10.623	6.659	18.001
Sikkim	-	-	0.131	0.131
Tamil Nadu	0.004	-	3.388	3.392
Tripura	-	-	0.108	0.108
Uttar Pradesh	1.295	-	35.4	6.635
West Bengal	0.85	-	1.327	2.177
UTs	0.016	-	0.873	0.889
All India	**7.165**	**12.926**	**73.600**	**93.691**

Source: Society for Promotion of Wastelands Development, New Delhi 1984

Table II.4.10

Progress of forest regeneration and afforestation.

(sq km)

Year	Area regenerated				
	By natural generation in existing tree forests	By coppice	By artificial regeneration		Total area regenerated and afforested
			In existing tree forests	*Afforested*	
1950/51	8000	2082	653	171	10906
1955/56	4496	2445	697	264	7902
1960/61	4445	4890	2955	660	12970
1965/66	7601	2760	3341	8439	22128
1970/71	13644	3129	762	944	19088
1975/76	8982	33784	---	1628	44394
1976/77[p]	7876	52847	---	2132	62855
1978/79[p,a]	8106	1957	12844	25020	47927
1978/79[p,a]	8359	1347	18571	11142	39419
1979/80[p,b]	10180	817	1059	1605	13661

[p] Provisional.

[a] Excludes the states of Assam, Goa, Madhya Pradesh, Manipur, Meghalaya, Nagaland, Orissa, Sikkim, West Bengal and the union territories of--Arunachal Pradesh, D & N Haveli, Delhi, Daman and Diu and Mizoram for which the data are not available.

[b] Excludes the states of Assam, Bihar, Goa, Haryana, Jammu & Kashmir, Madhya Pradesh, Manipur, Meghalaya, Nagaland, Sikkim, Tripura, West Bengal and union territories of Arunachal Pradesh, D & N Haveli, Delhi, Daman and Diu and Mizoram for which the data are not available.

Sources: [1] Central Statistical Organisation (CSO), Statistical Abstract, GOI, New Delhi, 1987;

[2] Department of Environment and Forests.

Table II.4.11
Major Produce of Forests ('000 cubic metres)

Year	Timber [a]	Pulp and match wood [b]	Firewood [c]	Total
1951/52	2820	1162	10710	14692
1955/56	3395	763	10810	14967
1960/61	4593	833	11642	17094[d]
1965/66	N.A.	693	13619	20554
1970/71	N.A.	9655	12090	21745
1975/76	N.A.	10772	15122	25894
1976/77 [p]	N.A.	8185	12412	20597
1977/78 [p]	N.A.	8303	14702	23005
1978/79 [p]	N.A.	7966	14304	22270
1979/80 [p]	N.A.	7561	13920	21481

[p] Provisional.
[a] Data on timber is included in pulp and match wood from 1965-66 onwards, since item-wise breakup is not available.
[b] Includes data on round wood.
[c] Includes charcoal wood.
[d] Includes 25000 cubic metres for which details are not available.

Sources: [1] Central Statistical Organisation (CSO), Statistical Abstract, GOI, New Delhi, 1987; and
[2] Department of Environment and Forests.

Table II.4.12

Roundwood production in selected countries of the world during 1985.

Countries	Industrial round wood	Fuelwood + Charcoal*	Total roundwood
USA	346566	101922	448488[a]
USSR	275400	80300	355700[a]
China	92652	170721	263373[a]
India	22592	222437	245019[a]
Brazil	57781	168124	225905[a]
Canada	165108	6197	171305
Indonesia	26811	122197	149008
Nigeria	7979	87587	95566
Germany (FR)	26855	3795	60650[a]
Sweden	48915	4424	53339[a]
Tanzania	1453	44087	45540[a]
Finland	38707	3075	41782
France	28575	10424	38999[a]
Ethiopia	1813	36083	37896[a]
Philippines	7442	29172	36614[a]
Japan	32944	521	33465
Kenya	1555	30854	32409[a]
Bangladesh	846	26298	27144
Vietnam	3250	21622	24872[a]
Rumania	19557	4569	24126[a]
Poland	19830	3510	23340
Mexico	7473	13844	21317
Pakistan	620	19613	20233
Australia	16343	2874	19217
Nepal	560	15216	15776[a]
Republic of Korea	2395	6178	8573
U.K.	4269	159	4428

* Roundwood equivalent of charcoal using a factor of 6.0 to convert from weight (mt.) to solid volume units (cu.m)

[a] Indicates FAO estimate.

Source: FAO, Yearbook of Forest Products - 1985.

Crop residues

Several renewable resources are abundantly available in the agro-processing centres, such as rice husk, bagasse, molasses, coconut shell, groundnut shell, maize cobs, potato waste, coffee waste and so forth. Likewise, organic residues such as rice straw, wheat straw, cotton sticks, jute sticks etc. are also available on farms. Such resources may be used as fuel, and in fact may be suited for several other applications also.

Agricultural commodities may be processed at the family level, in small processing units or modern mills. Therefore, the quantity and quality of residues available at each site, depends not only upon the specific agro-climatic conditions of a region, but also on the scale and efficiency of the processing unit.

The data-base on the availability of crop residues is very inadequate. However, some estimates based on normative residue-to-crop yield ratios are presented. The same ratios are used to estimate the residue yield during the time period 1950/51 to 1983/84, for want of better estimates; although this may not be correct. For instance, grain yield of bajra (pearl millet) may vary from 3 to 4 tonnes/hectare, and the straw yield from 1.2 to 9 tonnes/hectare, depending on whether the crop is grown in an irrigated area or not, whether high yielding variety seeds are used or not, and several other factors such as type of soil, sunshine hours, fertilizer usage pattern etc. As at least the first two factors have changed substantially over the past two decades or so, it is clear that the estimates presented in Table II.4.13 are very tentative.

Crop residues may be utilized as fuel, fertilizer, feed, as well as building material, industrial material and in chemical formulations. However, in view of the need for decentralized energy supply for agro-industrial processing and for rural homes, their use as fuel is of primary importance. For example, rice husk is used to supply energy for rice milling and tobacco curing, as also in the brick industry. Similarly bagasse, which is an important by-product of the sugar industry, is used mostly in the sugar industry itself, either as boiler fuel to generate steam, or for boiling and concentrating sugarcane juice. It is also used in paper making. Likewise, coconut shell which has been used traditionally as fuel for copra kilns, lime kilns and brick kilns, can also be used to yield gas, charcoal, acetic acid, wood spirit and phenol through destructive distillation.

Table II.4.13

Potential availability of agriculture based biomass.

	1960-61	1970-71	1981-82	1985-86	1987-88	1988-89	1989-90
A. Potential availability of rice husk							
Cropped area	34128	37592	40708	40912	38806	41736	42177
Rice production ('000 tonnes)	34574	42225	53248	64153	56862	70489	74053
Rice husk availability ('000 tonnes)	17287	21112	26624	32076	29431	35245	37027
B. Potential availability of wheat straw							
Cropped area ('000 hectares)	12927	18241	22144	23074	23063	24109	23457
Wheat production ('000 tonnes)	10997	23832	37452	46885	46169	54110	49652
Wheat straw availability ('000 tonnes)	14626	31696	49811	62357	61405	71966	66037
C. Potential availability of maize cobs							
Cropped area ('000 hectares)	4407	5852	5935	5879	5561	5897	5858
Maize production ('000 tonnes)	4080	7486	6897	6890	5721	8229	9409
Cob availability ('000 tonnes)	1224	2246	2069	2067	1716	2469	2823
D. Potential availability of bajra straw							
Cropped area ('000 hectares)	11469	12913	11784	10689	8713	12046	10890
Bajra production ('000 tonnes)	3283	8029	5537	3683	3998	7780	6620
Straw availability ('000 tonnes)	5450	13328	9191	6113	6637	12915	10989

contd...

Table II.4.13 (contd.)

Potential availability of agriculture based biomass.

	1960-61	1970-71	1981-82	1985-86	1987-88	1988-89	1989-90
E. Potential availability of ragi straw							
Cropped area ('000 hectares)	2515	2472	2611	2354	-	2320	2367
Ragi production ('000 tonnes)	1838	2155	2961	2518	2325	2379	2781
Straw availability ('000 tonnes)	8822	10344	14213	12086	11160	11419	13349
F. Potential availability of small millet straw							
Cropped area ('000 hectares)	4955	4783	3786	3168	-	2832	2598
Millet production ('000 tonnes)	1909	1988	1638	1217	1169	1151	1112
Straw availability ('000 tonnes)	4868	5069	4177	3103	2981	2935	2836
G. Potential availability of bagasse							
Cropped area ('000 hectares)	2415	2615	3193	2862	3279	3329	3405
Sugarcane production ('000 tonnes)	110001	126368	186358	171681	196737	203037	222628
Bagasse availability ('000 tonnes)	36667	42122	62119	56654	64923	67002	73467
H. Potential availability of coconut shell, fibre and pith							
Cropped area ('000 hectares)	717	1046	1091	1209	1346	1473	-
Coconut production (million nuts)	4639	6075	5573	6620	7270	8161	-
Shell availability ('000 tonnes)	626	820	752	893	982	1102	-
Fibre availability ('000 tonnes)	761	996	914	1085	1192	1338	-

contd...

Table II.4.13 (contd.)

Potential availability of agriculture based biomass.

	1960-61	1970-71	1981-82	1985-86	1987-88	1988-89	1989-90
Pith availability ('000 tonnes)	1141	1494	1371	1628	1788	2008	-
I. Potential availability of groundnut shell							
Cropped area ('000 hectares)	6463	7326	7429	7311	6844	8529	8707
Groundnut production ('000 tonnes)	4812	6111	7223	5121	5854	9659	8088
Shell availability ('000 tonnes)	1604	2037	2407	1830	1932	3187	2669
J. Potential availability of cotton stalks							
Cropped area ('000 hectares)	7610	7605	8057	7581	6459	7342	7331
Cotton production ('000 bales of 170 Kg)	5604	4763	7884	8612	6382	8744	11414
Cotton stalks availability ('000 tonnes)	22830	22815	24171	22743	19377	22026	21993
K. Potential availability of jute sticks							
Cropped area ('000 tonnes)	629	749	826	1148	697	691	679
Jute production ('000 bales of 180 Kg)	4134	4938	6788	10952	5793	6710	7112
Jute sticks availability ('000 tonnes)	1887	2247	2478	3444	2091	2073	2037

A. Rice husk : 0.5 by weight of clean rice.

B. Wheat straw : 1.33 by weight of wheat grain.

C. Maize cobs : 0.3 by weight of maize grain.

D. Bajra straw : 1.66 by weight of bajra gain.

E. Ragi straw : 4.8 by weight of ragi.

F. Small millet : 2.55 by weight of millet.

G. Bagasse : 0.33 by weight of sugarcane.

H. Coconut shell, : 1 coconut yields 135g shell, 164g fibre and Fibre Pith 246g pith.

I. Groundnut shell: 0.33 by weight of groundnut produced.

J. Cotton stalks : 3 tonnes of cotton stalks produced per hectare.

K. Jute sticks : 3 tonnes of jute sticks produced per hectare.

Sources: [1] Central Statistical Organisation (CSO), Statistical Abstract, GOI, New Delhi, 1987;
[2] The source for potential availability of rice husk is Fertilizer Association of India, Fertilizer Statistics, 1983-84;
[3] For wheat, bajra, ragi and small millet: ICAR, Handbook of Agriculture;
[4] For maize cobs, bagasse, groundnut shell, cotton stalks and jute sticks: O.P. Vimal and P.D. Tyagi, Energy From Biomass, Agricole Publishing Academy, New Delhi, 1984; and
[5] For coconut shell, fibre and pith: TERI Report on 'Potential for Renewable Energy Utilization in Andaman & Nicobar and Lakshadweep Islands', Prepared for DNES.

Animal wastes

Dung, poultry excreta etc. are available in abundance in animal sheds, poultry farms etc. The quantity of waste available of course, depends on the weight and age of animals. It may vary from 0.04 kg/day in case of hens to 15 kg/day from buffaloes. However, not all dung that is available may be collected; and not all dung that is collected, may in fact be used as fuel. The utilization rate in a particular area depends upon the climate and fuelwood availability; and also varies with season.

With an increase in livestock population since the early fifties,the availability of animal wastes may be considered to have increased significantly during the past four decades. Little data however, are available on its method of collection and utilization, except from some sample surveys (in which actual measurements were not made).

Table II.4.14

Livestock Population ('000)

	1951	1961	1972	1977	1982	1988	1989
Cattle	155295	175557	178341	180140[9]	192453[9]	193000	195500
Buffaloes	43400	51210	57426	62029	69784[9]	72000	73700
Sheep	39052	40223	39993	40907	48765	51684	53486
Goats	47155	60864	67518	75620	95255	105000	107000
Horses & ponies	1515	1327	942	916	900	1088*	1093*
Other livestock	6367	7251	9118	9914	12432	-	-
Total	**292784**	**336432**	**353338**	**369526**	**419588**	**-**	**-**

[9] includes figures for Arunachal Pradesh (1977 census) and Punjab (projected). The difference in total is due to the projected figure for Punjab.

* FAO Estimate.

Sources: [1] Central Statistical Organisation (CSO), Statistical Abstract, GOI, New Delhi, 1987;
[2] FAO, Yearbook. 1989.

Table II.4.15

Dung production in various states.
(Kg/bovine/day)

Andhra Pradesh	3.6
Bihar	3.6
Gujarat	3.7
Haryana	6.8
Himachal Pradesh	5.3
Katnataka	2.9
Kerala	2.6
Madhya Pradesh *	2.6
Maharastra	3.2
Punjab	7.0
Rajasthan **	5.7
Tamil Nadu	5.8
Uttar Pradesh	4.7

Estimates based on surveys covering only western parts of the State.

** Estimates based on surveys covering only about 2/3 of the State.

Source: Goel BBPS et al, Indian Journal of Animal Science, 1973, 43; as quoted in Vimal and Tyagi, Energy Form Biomass, Agricole Publishing Academy, New Delhi, 1984.

City wastes

Garbage or municipal solid waste, which is considered to be a potent source of environmental pollution, can meet a significant portion of urban energy needs if tapped efficiently. The traditional practice of using it as a land-fill, may not be the best way of utilizing it, not only because it is insanitary and malodorous, but also because it gets putrefied gradually, and the liquids seep into the soil and ultimately pollute the ground water reservoirs.

Although the city wastes in India are only about 0.4 kg per day per city dweller (compared to 1 kg in Japan and about 2 kg in USA), the total quantities in India are very large. As about 60% of the waste is non-compostable, the problem is quite serious, and the quantity of putrescible is significantly higher than in the European countries.

Any changes in the existing patterns of waste disposal or utilization may be made rationally only if there is adequate knowledge of its physical and chemical characteristics. The information collected through a detailed survey of various cities is summarized in the following tables.

Table II.4.16
Potential availability of city refuse.

	Urban Population (million)	City Refuse (million tonnes/year)		
		Total[a]	Non-compostable	Compostable[b]
1970/71	110.2	16.09	9.65	6.44
1975/76	134.5	19.64	11.78	7.86
1980/81	157.7	23.02	13.81	9.21

[a] 0.4 kg/urban dwellers/day (Vimal and Tyagi, 1984).
[b] 60% is non-compostable; 40% is compostable (Vimal & Tyagi, 1984).

Table II.4.17.
Chemical Characteristics of City Refuse

	Population range of city (millions)			
	< 0.2	0.2-0.5	0.5-2.0	> 2.0
Moisture (%)	22.12	25.05	22.45	31.18
pH	8.18	8.16	8.34	7.68
Organic matter (%)*	22.02	22.51	21.51	27.57
Carbon (%)*	12.26	12.51	11.95	15.32
Nitrogen (%)*	0.6	0.61	0.56	0.58
Phosphorous P_2O_5 (%)*	0.71	0.72	0.68	0.59
Potash K_2O (%)*	0.71	0.74	0.72	0.68
Calorific value (kCal/Kg)	801	874	867	1140

* On a dry weight basis.

Source: Bhide et al. India Journal of Environmental Health, 1973, 17(3), as quoted in Vimal and Tyagi, Energy from Biomass, Agricole Publishing Academy, New Delhi, 1984.

Table II.4.18

Physical analysis of city refuse.

Name of the city	Sample	Paper	Rubber & Leather	Plastics	Rags	Wood	Metals	Glass	Coal	Crockery	Bricks	Matters	Earth
Aurangabad	Summer	3.88	0.31	0.50	2.21	0.23	0.34	0.65	0.31	0.33	8	41.69	
	Winter	5.13	0.99	0.05	4.51	2.00	0.70	0.69	0.68	0.46	10.74	30.9	38.25
Bangalore	Summer	1.08	0.11	0.38	0.58	0.14	0.25	0.24	0.69	0.45	1.42	42.59	52.06
	Winter	2.75	0.08	0.26	0.91	0.07	0.36	0.18	0.15	0.21	0.95	65.07	29.11
Calicut	Summer	6.61	0.19	1.65	3.55	0.07	0.34	0.05	0.26	0.16	-	61.59	25.53
	Winter	5.45	0.12	1.84	0.98	1.60	0.41	0.07	0.04	0.21	1.32	70.5	17 38
Coimbatore	Summer	2.98	0.31	0.18	3.12	0.48	0.49	0.43	0.17	0.1	8.71	43.72	39.5
	Winter	3.17	0.89	0.08	5.35	0.33	0.59	0.36	1.36	0.33	8.88	26.76	51.76
Gwalior	Summer	5.01	0.85	0.66	3.09	0.62	0.79	0 45	2.42	0.26	5.54	27.47	53 5
	Winter	4.15	0.25	0.65	0.94	0.43	0.35	0.3	0.98	0.52	2.62	32.58	58.66
Jabalpur	Summer	2.69	0.60	0.90	2.52	2.23	0.46	0.56	2.55	0.79	5.63	49.85	28.75
	Winter	1.33	0.39	0.48	0.89	0.49	0.31	0.15	1	0.26	2.13	29.89	58.85
Madurai	Summer	7.94	0.52	2.10	3.94	3.23	0.8	0.33	2.58	0.18	2.01	22 45	53.78
	Winter	7.68	0.66	0.77	4.52	2.23	0 59	0.71	3.23	0.05	2.34	30.57	46.66
Patna	Summer	3.71	0.25	0.16	2.42	0.56	0.07	0.06	9.84	0 02	7.07	25.21	50.03
	Winter	2.29	0.89	0.24	3.89	0.62	0.47	0.24	6.58	0.01	7.25	21.27	56.34
Surat	Summer	3.25	0.26	1.03	2 16	0.13	0.4	0.36	0.8	0.3	2.62	48.05	40.59
	Winter	2.80	0.31	0.99	2 28	0.14	0.34	0.2	0.73	0.25	1 68	40 47	49 6
Trichinapalli	Summer	7.42	0.29	2.39	5.07	2.59	0.3	1.56	2.93		1.82	41.53	34.64
	Winter	3.72	5 93	0.84	7.64	0.19	0.28	1	0.8	0.26	0.66	50.45	28.7
Trivandrum	Summer	3.35	0.66	1.35	0.19	0.03	0.6	0.06	0.18	0.51	0.21	72.33	20.36
	Winter	3.88	0.05	0.51	2.67	1.41	0.15	0.22	0.39	0.4	2.52	71.22	16.58
Udaipur	Summer	2.70	0.07	0.22	2.80	0.63	0.1	0.4	1.37	0.2	3.26	32.43	56.64
	Winter	2 06	1.39	0.34	3.55	3.32	0 21	0 73	0.51	0.87	10	29.62	46 83
Ahmedabad	Summer	2.41	0.33	0.34	4.16	2.05	0.51	0.36	0.36	1 05	5.73	54.52	8 28
	Winter	3.85	0.42	1.03	4.20	2 08	0.45	0.24	1.59	0.08	2 79	45.78	38
	Monsoon	2.79	0.20	1.14	3.97	1.96	0.29	0.09	0.35	0.59	5.49	47.62	36 02
Allahabad	Summer	2.96	0.17	0.17	3.42	2.64	0.24	0.34	2.45	0.87	7.98	43.52	34.46
	Winter	3.39	0.05	0.67	2 37	1 31	0.38	0 47	3.71	0.37	8.15	39 51	39.19
	Monsoon	5.13	1.42	1.22	2.05	1 10	1.05	0.36	4.58	0.22	5 41	50.49	32 23
Baroda	Summer	3 15	0.43	0.35	2 29	1 37	1.13	0.19	1.83	0 61	8 52	32.65	47 25
	Winter	2 93	0.16	0.36	3.01	1 99	0 49	0.48	0.61	1.29	6.98	43.10	39 36
	Monsoon	8.27	0.38	0.22	4.65	9.79	0.18	0.09	0.16	0.11	4 86	42.00	29 80
Bhopal	Summer	7 63	0.93	0.37	4.46	1.84	0.66	1.63	1.56	0.03	13.76	34.81	32 56
	Winter	5.58	0.68	0.73	5 05	0.58	0.40	0.25	2.47	0.04	4.12	46 40	33 61
	Monsoon	9 92	0.39	0 56	6.63	2 78	0.63	0.28	3.82	0.04	12 35	34 83	28 37

contd

Table II.4.18 (contd.)

Physical analysis of city refuse.

Name of the city	Sample	Paper	Rubber & Leather	Plastics	Rags	Wood	Metals	Glass	Coal	Crockery	Bricks	Matters	Earth
Chandigarh	Summer	6.88	0.32	0.15	7.16	0.36	0.28	0.22	7.83	0.00	1.57	40.62	34.38
	Winter	6.66	0.44	0.08	3.59	2.12	0.26	0.12	9.55	0.01	1.51	42.21	38.41
	Monsoon	4.97	0.07	0.77	4.97	1.15	0.13	0.28	3.15	0.08	17.06	21.44	5.29
Delhi	Summer	8.20	1.73	0.66	5.31	0.59	0.71	0.32	7.82	0.05	6.43	43.14	24.96
	Winter	7.85	1.31	1.56	6.75	1.26	1.91	1.11	1.47	0.00	11.24	30.89	34.36
	Monsoon	2.83	0.77	0.33	2.04	1.06	1.02	0.29	3.39	0.34	9.15	32.22	49.16
Hyderabad	Summer	5.76	0.49	0.70	4.80	2.77	0.95	1.06	1.93	1.46	8.20	37.83	34.50
	Winter	4.31	0.58	0.45	2.01	0.88	0.21	0.60	6.16	0.16	10.13	24.04	49.62
	Monsoon	4.37	0.84	1.36	2.69	1.66	2.51	1.14	3.41	0.46	8.71	50.51	23.03
Jaipur	Summer	2.12	0.38	0.81	2.99	1.59	0.49	0.57	2.33	0.00	13.73	24.75	50.29
	Winter	2.98	1.17	0.59	4.88	3.32	0.36	0.53	0.42	0.28	9.63	22.75	53.13
	Monsoon	3.98	1.35	1.01	9.18	2.60	1.08	0.06	0.06	0.01	4.51	30.17	46.15
Kanpur	Summer	3 25	0 70	0.57	3.00	0.51	0.40	0.61	1.60	0.58	4.27	43.22	38.41
	Winter	3.34	1 52	0 75	3.85	1 47	0.72	0.27	6.76	0.92	12.97	39.51	39.21
	Monsoon	2.28	0.27	0.53	1.48	1.32	0.24	0.25	2.20	0.15	3.07	40.53	60.91
Madras	Summer	9.86	0 46	1.58	6.60	1.74	1.32	1.44	2.86	0.00	6.21	45.30	23.22
	Winter	4.72	0.59	0.54	3 39	1.59	0.72	1.00	3.25	0.36	5.74	48.01	29.13
	Monsoon	8.96	0.34	0.52	4 60	0.47	0.81	0 46	0.41	0.06	3.11	50.61	29.63
Rourkela	Summer	2.63	1.23	3.15	5.06	1.21	0.98	0.07	8.60	0.00	3.08	25 87	48.60
	Winter	4.52	5.82	0.00	5.70	1 60	1.17	0.19	1.88	0.11	2.41	29.50	47 26
	Monsoon	3.42	0.04	0.77	2.61	0.16	1.39	0.24	0.23	0.27	1.64	38.19	51.35

Source . National Environmental Engineering Research Institute (NEERI), Report on 'Characterisation of Bombay City Refuse'

Table II.4.19

Chemical analysis of cities refuse*

Name of the City	Sample	Moisture (%)	pH	Organic matter (%)	Carbon (%)	Nitrogen (%)	Phosphorous as P_2O_5 (%)	Potassium as K_2O (%)	C/N Ratio	HCV in BTU/lb
Aurangabad	Summer	14 89	7 94	21 85	12 67	0.56	0.73	0.39	22.49	1218.90
	Winter	21 57	7 60	19 19	11 13	0 60	0.76	0 64	18.40	955 10
Bangalore	Summer	43 29	8 63	19.33	10.74	0.60	0 92	0.90	17.69	1145 00
	Winter	23 00	8 68	21 03	11 71	0 49	0 70	1.31	18 01	1471.00
Calicut	Summer	53 25	8.23	31.58	17 54	0.69	1.18	0.71	25.43	1739.00
	Winter	17 62	7 42	19 30	10.73	0.46	0 48	0.31	23.33	1303.00
										contd

Table II.4.19 (contd.)

Chemical analysis of cities refuse*.

Name of the City	Sample	Moisture (%)	pH	Organic matter (%)	Carbon (%)	Nitrogen (%)	Phosphorous as P_2O_5 (%)	Potassium as K_2O (%)	C/N Ratio	HCV in BTU/lb
Coimbatore	Summer	12.93	8.20	26.02	14.45	0.76	0.80	1.00	18.78	1704.00
	Winter	26.64	8.50	24.15	14.00	0.54	0.59	1.14	25.75	2179.00
Gwalior	Summer	17.86	8.44	19.60	10.88	0.59	1.03	0.99	18.46	1239.00
	Winter	19.54	7.91	25.25	14.46	0.86	0.56	1.11	16.96	2129.00
Jabalpur	Summer	9.42	8.27	26.62	14.78	0.71	0.80	0.58	20.64	1742.84
	Winter	23.79	8.40	24.07	13.96	0.57	0.50	0.97	24.45	2156.16
Madurai	Summer	17.98	8.52	31.72	17.61	0.88	0.86	1.03	20.01	2192.00
	Winter	35.71	8.14	19.33	11.21	0.76	0.52	0.94	14.69	1706.20
Patna	Summer	13.53	9.07	16.31	9.05	0.55	0.80	0.63	16.45	966.90
	Winter	14.26	7.83	11.96	6.78	0.56	0.75	0.84	12.07	1305.41
Surat	Summer	16.88	7.68	17.52	9.33	0.51	0.79	0.58	18.36	1217.00
	Winter	22.01	7.18	28.28	15.90	0.82	0.61	0.64	17.96	2263.00
Trichinapalli	Summer	42.49	7.87	37.24	20.68	1.16	0.67	1.13	17.72	2635.00
	Winter	42.56	7.86	26.17	15.18	0.69	0.75	0.81	21.96	2409.00
Trivandrum	Summer	31.82	6.80	28.53	15.85	0.80	0.48	0.33	15.48	1967.90
	Winter	21.99	7.01	24.45	13.50	0.83	0.50	0.65	18.78	2046.49
Udaipur	Summer	13.73	7.98	26.65	14.81	0.81	0.71	0.94	18.38	1727.00
	Winter	16.88	8.58	28.50	15.70	0.86	0.85	1.15	18.88	2174.00
Ahmedabad	Summer	16.78	8.37	28.99	16.10	0.41	0.38	0.57	39.20	2158.50
	Winter	23.87	7.89	28.48	15.80	0.55	0.71	0.52	28.90	1934.20
	Monsoon	34.78	8.37	18.08	10.00	0.46	0.51	0.48	21.70	1230.90
Allahabad	Summer	11.09	8.43	19.38	11.25	0.62	0.41	0.55	18.16	1323.36
	Winter	16.86	8.54	17.17	9.96	0.41	0.58	0.84	24.05	1318.79
	Monsoon	21.72	8.11	13.12	7.61	0.53	0.63	0.58	14.46	1287.62
Baroda	Summer	19.99	8.61	22.08	12.45	0.61	0.55	0.45	220.32	1250.70
	Winter	15.78	7.94	21.97	12.20	0.72	0.79	0.67	17.05	1414.02
	Monsoon	29.92	8.33	19.39	10.77	0.59	0.46	0.45	18.37	1585.79
Bhopal	Summer	13.40	7.89	35.74	19.85	0.72	6.71	0.97	27.56	2759.40
	Winter	26.28	8.82	32.88	18.26	0.68	0.69	1.33	26.85	2335.70
	Monsoon	43.56	8.77	23.51	12.61	0.68	0.61	0.68	18.82	1856.70
Chandigarh	Summer	27.58	7.09	27.35	15.19	0.54	0.59	0.60	28.07	2205.00
	Winter	36.36	7.90	22.72	12.62	0.51	0.48	0.53	24.59	1795.11
	Monsoon	15.06	8.37	20.85	11.58	0.54	0.42	0.56	20.86	1472.36
Delhi	Summer	27.42	7.68	24.50	13.57	0.51	0.56	0.51	26.60	2431.92
	Winter	39.39	7.56	36.77	20.41	0.77	0.93	0.76	26.52	2845.16
	Monsoon	14.40	8.29	15.00	8.33	0.51	0.64	0.51	16.36	1286.52

contd...

Table II.4.19 (contd.)

Chemical analysis of cities refuse*.

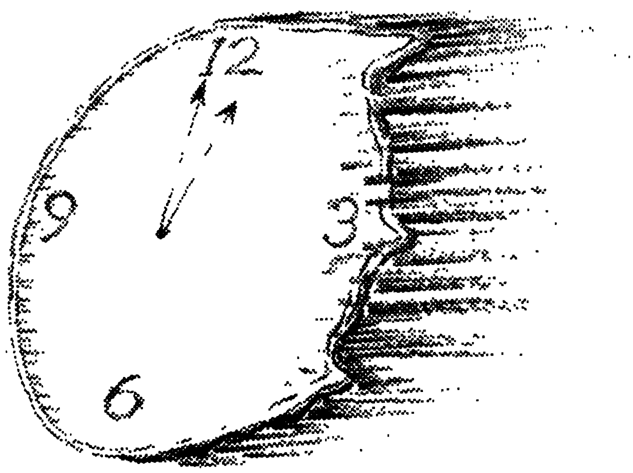
Name of the City	Sample	Moisture (%)	pH	Organic matter (%)	Carbon (%)	Nitrogen (%)	Phosphorous as P_2O_5 (%)	Potassium as K_2O (%)	C/N Ratio	HCV in BTU/lb
Hyderabad	Summer	6.39	8.54	26.60	17.40	0.61	0 50	0.68	28.50	2512.40
	Winter	14.90	8.09	27.69	19.31	0.65	0.64	0.59	29.69	2499.30
	Monsoon	12.90	8.68	23.45	12.80	0.53	0.62	0.57	24.18	2074.50
Jaipur	Summer	15.44	8.55	11.74	6.52	0.47	0.51	0.45	13.90	773.50
	Winter	17.23	8.41	14.36	7.99	0.33	0.83	0.58	24.90	952.00
	Monsoon	30.49	7.82	21.12	11 70	0.51	1.01	0.51	22.90	1109.60
Kanpur	Summer	12.56	8.31	20.91	12.13	0.61	0.65	0.83	19.92	1272.75
	Winter	21.64	7.91	23.50	13.63	0.50	0.89	6.16	27.53	1422.37
	Monsoon	21.49	8.41	18.62	10.80	0.58	0.51	0.47	18.65	1139.50
Madras	Summer	27.35	7.52	31.32	14.72	0.56	0.45	0.73	26.33	2067.74
	Winter	38.30	7.67	34.75	15.38	0.57	0.57	0.94	26.88	1868.64
	Monsoon	40.25	7.35	23.06	13.03	0.60	0.40	0.62	21.78	1838.92
Rourkela	Summer	15 60	9.67	25.27	14.04	0.47	0.90	0.67	29.66	1999.80
	Winter	12.83	8.06	21 37	11.87	0.52	1.05	0.49	22.66	1555.80
	Monsoon	23.42	9.22	19.75	10.97	0.62	0.61	0.41	17.65	1768 20

*All values but moisture are calculated on a dry weight basis

Source: National Environmental Engineering Research Institute (NEERI), Report on 'Characterisation of Bombay City Refuse', prepared for Municipal Corporation of Greater Bombay, 1984-85.

Energy demand

When every minute counts,



every bit of energy is precious.

With every passing day, India takes another stride into the 21st century. Making rapid progress in almost every vital sector of the economy. But with every leap forward that the country takes, grows the burden on its energy resources – the very life of the nation. And now, under the crunch of the mounting energy crisis, the pressure is really high.

The demand for oil and other energy sources has left the supply way behind. And the gap keeps widening everyday. The need of the hour, then, is to look for new sources to bridge this gulf, step up indigenous oil production, save every single drop of oil and conserve every bit of energy we can.

At a time like this, we, at ONGC are really sticking our necks out. One of our major thrust areas has always been energy conservation and development of alternate sources of energy. And now, our efforts are reaching a new peak. We're expanding our exploration efforts and striving to reduce India's dependence on oil imports through increased productivity. We're continuously evolving new strategies and setting targets to cut down our consumption rate. We're conducting regular energy audits and monitoring. Our energy efficient equipment is helping us save up to Rs. 50 lakhs a year. We're continually tapping non-conventional, renewable forms of energy like solar and wind energy. And creating an awareness, so that you, and every single Indian might join us in making a conscious effort at conserving our precious energy resources.

Time is short. We need to act now. The other side of midnight may just be too late.

ONGC

OIL & NATURAL GAS COMMISSION
Tel Bhawan, Dehradun 248 003.

Pratibha/ONGC/237/91-C

Energy demand

Overview

In trying to identify the determinants of energy demand, economists have studied several issues, including the level of economic development, relative energy consumption levels in the various economic sectors and sub-sectors, major energy consuming activities in a particular sector, type/vintage/cost/other characteristics of energy consuming equipment in use, energy prices, and so on.

To get a good feel of the energy demand aspects obviously entails very large data base requirements. Such data are not usually compiled systematically in developing countries, including India. However, an attempt is made here to present energy and related data for major energy consuming activities in following sections.

Background data on the composition of India's gross domestic product (GDP), population, energy imports and per-capita commercial energy consumption are also presented. According to the official estimates by the Energy Demand Group, 1986 [CMIE,1990], commercial energy accounted for about 58% of the total energy demand in 1984-85. This share is projected to grow to almost 80% by 2004-05. The total energy demand in 1989-90 was 1,025 mtcr[1]. About two-thirds of this demand was met through the commercial sources of energy. Between 1984-85 and 1989-90, the total energy demands estimated to have grown at the rate of 6.7% per annum from 741 to 1,025 mtcr. This growth rate is expected to fall to an average of 4.5% per annum during the Eighth Plan period and edge up to 5% per annum between 1994- 2000. The total energy demand is projected to more or less double from the 1,025 mtcr in 1989-90 to 2,046 mtcr in 2004-05. Details of the estimates and the projections made by the group are also presented.

It could be observed that the transport sector is likely to register the largest increase in the demand on the energy resources in future. The industrial sector would continue to be the largest consumer of energy. The share of agriculture in the total energy demand is likely to fall. It may be noted that although the commercial energy consumption per-capita has increased gradually since the early seventies, it still remains at less than 10% of the levels achieved in the industrialized market economies. Even if the

[1]Energy data in India is compiled in either coal replacements units, that measure the calorific content of an energy source. By using coal replacement units, one effectively compiles data on useful energy demand. It is therefore evident that while coal or oil equivalent units are used for aggregation, the share of non-commercial energy will be higher.

contribution of traditional energy forms is considered, the total energy consumption per-capita remains far below the levels of the industrialized nations.

Table III.1.1

Sectoral energy demand.

		1984-85	1989-90	1994-95	1999-00	2004-05
Total demand (mtcr)		**741**	**1025**	**1276**	**1631**	**2046**
Sectoral shares in per cent of demand						
Industry	A	18.2	21.1	22.7	24.8	25.2
	B	31.4	31.5	32.0	33.1	31.7
Transport	A	15.0	17.1	18.9	19.6	21.6
	B	25.5	25.5	26.6	26.1	27.1
Agriculture	A	3.8	3.9	3.7	3.4	2.9
	B	6.5	5.9	5.2	4.5	3.6
Household						
Commercial	A	5.0	7.6	9.3	10.9	12.9
	B	3.6	11.4	13.1	14.6	16.2
Non-commercial	A	41.9	33.2	29.0	25.1	20.5
	B	-	-	-	-	-
Others	A	2.2	2.3	2.5	2.8	3.0
	B	4.0	3.5	3.5	3.7	3.7
Auxiliary consumption	A	13.9	14.8	13.9	13.4	14.0
	B	24.0	22.2	19.6	18.0	17.6
		100.0	100.0	100.0	100.0	100.0

A: % of total energy demand

B: % of commercial energy demand

Source: Current Energy Scene in India, July 1990, CMIE.

Table III.1.2
GDP at factor cost by industry of origin (Rs. million, 1980/81 prices).

	1970/71	1980/81	1984/85	1986/87	1987/88	1988/89*	1989/90@
Agriculture, forestry & logging, mining & quarrying	378110	483660	564400	558500	561640	651280	669020
Manufacturing, construction, electricity, gas & water supply	184316	297470	388410	455940	471210	499050	532630
Transport, communication & trade	145337	204370	257870	291920	307990	338130	360620
Banking & insurance, real estate & ownership of dwellings & business services	48601	108410	135710	154670	167060	184560	195330
Public administration, defence & other services	68189	128350	159030	183380	199260	204230	216590
Total	**824553**	**1222260**	**1505420**	**1644410**	**1707160**	**1877250**	**1974190**

* Provisional
@ Quick est.
Source: Central Statistical Organisation, National Accounts Statistics, various issues.

Table III.1.3
Population and trends in urbanization.

	Total population (million)*	**Urban population %**
1950	359	17.3
1960	434	18.0
1970	541	19.9
1980	679	23.7
1986	771	24.9
1987	785	26.1
1988	802	--
1989	820	--

* As on September 1.

Source: Centre for Monitoring Indian Economy, Basic Statistics Relating to the Indian Economy, vol. 1: All India, Bombay, August 1990.

Table III.1.4

Net imports of crude oil and petroleum products.

	Net imports of crude oil and petr. products ('000 tonnes)	As a % of total imports	As a % of total exports
1970/71	12435	8.1	8.6
1975/76	15672	23.6	30.8
1976/77	16598	27.9	27.6
1977/78	17339	25.7	28.6
1978/79	18491	24.6	29.3
1979/80	20757	35.5	50.6
1980/81	23501	41.9	78.4
1981/82	19289	36.6	63.8
1982/83	16630	30.8	50.0
1983/84	13301	20.5	32.7
1984/85	12323	20.5	29.7
1985/86	16518	21.8	39.6
1986/87	16033	11.8	19.0
1987/88	18269	15.2	21.4
1988/89	21774	13.7	19.2
1989/90*	23440	15.9	30.1

* Provisional.

Sources: [1] Ministry of Petroleum and Natural Gas, Indian Petroleum and Natural Gas statistics, 1989-90.

[2] GOI, Ministry of Finance, Economic Survey, 1990-91.

Table III.1.5
Per-capita consumption of commercial energy (toe).

1981	0.0996
1982	0.1058
1983	0.115
1984	0.1137
1985	0.1152
1986	0.1218
1987	0.1255
1988	0.1304
1989	0.226

Sources: [1] CMIE, Basic Statistics Relating to the Indian Economy Vol 1: All India, August 1989.
[2] WDR, 1991.

Agriculture

Introduction

Agricultural productivity, and hence value added, depend upon several factors including the area of land under cultivation, extent of multiple cropping, the choice of crop, use of high yielding varieties, use of organic and inorganic fertilizers, the coverage of surface and ground-water irrigation schemes, the extent of mechanization for land preparation and so forth.

Although over 60% of India's economically active population is engaged in agriculture, the share of gross value added from this sector to total GDP, has been falling and stands around 29% now.

India ranks third, next only to the USSR and USA, as far as the total arable land area is concerned. However, on a per-capita basis, the arable land area of 0.22 hectares in India is much less than the average of 0.32 hectares for the 21 selected countries (Table III.2.1).

The consumption of inorganic fertilizers in India in 1986/87 was only 57.1 kg/hectare of arable land. In Japan, it was as high as 427.1 kg. In most countries other than Burma, Brazil and the Philippines, inorganic fertilizer consumption seems to be more intensive than in India. Therefore, there could be a substantial scope for increasing agricultural output in India. This becomes clear from a comparison of yield/hectare of major rice and wheat growing countries.

Another interesting feature about Indian agriculture is the increase in the number of land holdings. However, the area under agriculture has remained more or less unchanged at around 162 million hectares, for at least two decades. Therefore, this increase in the number of land holdings is the outcome of a "downward compression of peasantry", which is marked by division and re- division of the erstwhile large holdings.

Table III.2.1

Agricultural indicators -- an international comparison**

	Economically active population in agriculture as % of total	Arable land* (million hectares)	Per papita arable land* (hectares)	Fertilizer consumption per hectare of arable land* (kg)
India	68	168.8	0.22	57.1
Bangladesh	71	9.2\	0.09	67.3
China	70	97.8	0.09	176.2
Pakistan	51	20.7	0.2	86.2
Sri Lanka	52	1.9	0.11	88.7
Burma	49	10.1	0.27	19.8
Egypt	42	2.5	0.05	319.3
Philippines	48	7.9	0.14	42.5
Brazil	26	76.8	0.55	42.5
Iran	30	14.8	0.32	60.9
Korea, Rep. of	28	2.1	0.05	385.3
Mexico	32	24.8	0.31	73.7
U.S.S.R.	15	232.2	0.83	114.1
Italy	8	12.2	0.21	169.2
Japan	8	4.7	0.04	427.1
France	6	19.0	0.34	309.1
Israel	5	0.4	0.10	223.6
Canada	4	46.0	1.80	47.4
Germany,W.	4	7.5	0.12	427.9
U.K.	2	7.0	0.12	379.8
U.S.A.	3	189.9	0.79	91.8

*: Including area under permanent crops.

**: Data relate to 1986 or 1987.

Source: Department of Economics & Statistics (Tata Services Ltd.), Statistical Outline of India, 1989-90, June 1989.

Table III.2.2
Yield of paddy*.

	Yield (100 kg/hectare)	
	1988	**1989**
India	25.42	25.90
Japan	58.86	61.68
China	52.78	55.37
Indonesia	41.11	42.28
Burma	27.56	28.53
Philippines	26.44	27.05
Vietnam	29.03	30.89
Bangladesh	23.63	25.02
Thailand	21.46	20.77
Brazil	19.81	21.06

* Relates to output and yield of major rice producing countries.

Source: FAO Yearbook, 1989, vol. 43.

Table III.2.3

Yield of wheat*.

	Yield (100 kg/hectare)	
	1988	1989
India	20.02	22.41
France	61.51	63.48
China	29.67	30.54
U.S.A.	22.91	22.03
Canada	12.32	17.88
Australia	15.79	16.09
Pakistan	17.34	18.65
U.S.S.R.	17.57	19.00
U.K.	61.72	66.00

* Relates to output and yield of major wheat producing countries.

Source: FAO Yearbook, 1989, vol. 43.

Table III.2.4

Value added from agriculture and allied activities (Rs. million, 1980/81 prices)

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
Value of output	568750	601630	597770	653750	659150	664280	660410	659640
Agriculture	462780	488720	479990	527300	524210	522000	511750	507460
Livestock*	105970	112910	117780	126450	134940	142200	148660	152180
Inputs	152470	158850	161130	165640	171730	175480	180360	176360
Gross value added in agriculture and allied activities	424660	451450	445700	497530	497020	498550	489950	493340
Gross value added to GDP (%)	34.7	34.8	33.3	34.3	32.9	31 4	29.6	28.9

* Includes value of output from hunting and trapping

Source: Central Statistical Organization, National Accounts Statistics, GOI, New Delhi, various issues.

Table III 2.5

Agricultural area of principal crops in India (mha).

Agricul-tural year	Rice	Wheat	Pulses	Coarse gains	Food-grains	Ground nut	Rapeseed & mustard	Oilseed	Suga-rcane	Cotton (lint)	Jute & mesta
1978-79	40.48	22.64	23.66	42.23	129.01	7.43	3.54	17.71	3.09	8.12	1.27
1979-80	39.42	22.17	22.26	41.36	125.21	7.17	3.47	16.94	2.61	8.13	1.22
1980-81	40.15	22.28	22.46	41.78	126.67	6.8	4.11	17.6	2.67	7.82	1.3
1981-82	40.71	22.14	23.84	42.45	129.14	7.43	4.4	18.91	3.19	8.06	1.15
1982-83	38.26	23.57	22.83	40.43	125.1	7.22	3.83	17.76	3.36	7.87	1.02
1983-84	41.24	24.67	23.54	41.71	131.16	7.54	3.87	18.69	3.11	7.72	1.05
1984-85	41.16	23.56	22.74	39.21	126.67	7.17	3.99	18.92	2.95	7.38	1.13
1985-86	41.14	23	24.42	39.47	128.02	7.12	3.98	19.02	2.85	7.53	1.5
1986-87	41.17	23.13	23.16	39.74	127.2	6.98	3.72	18.63	3.08	6.95	1.07
1987-88	38.81	23.06	21.27	36.55	119.69	6.84	4.62	20.13	3.28	6.46	0.96
1988-89	41.73	24.11	23.15	38.68	127.67	8.53	4.83	21.9	3.33	7.34	0.92
1989-90	42.17	23.46	23.22	37.66	126.51	8.71	4.99	22.97	3.41	7.33	0.91

Source: Ministry of Agriculture, Directorate of Economics and statistics, 'Agricultural statistics at a glance'.

Table III 2.6

Production of principal crops in India (mt)

Agricultural year	Rice	Wheat	Pulses	Coarse gains	Food-grains	Ground nut	Rapeseed & mustard	Oilseed	Sugarcane	Cotton* (lint)	Jute* & mesta
1978-79	53.8	35.5	12.2	30.4	131.9	6.2	1.9	10.1	151.7	8	8.3
1979-80	42.3	31.8	8.6	27	109.7	5.8	1.4	8.7	128.8	7.7	8
1980-81	53.6	36.3	10.6	29	129.6	5	2.3	9.4	154.2	7	8.2
1981-82	53.2	37.4	11.5	31.1	133.3	7.2	2.4	12.1	186.4	7.9	8.4
1982-83	47.1	42.8	11.9	27.8	129.5	5.3	2.2	10	189.5	7.5	7.2
1983-84	60.1	45.5	12.9	33.9	152.4	7.1	2.6	12.7	174.1	6.4	7.7
1984-85	58.4	44.1	12	31.2	145.5	6.4	3.1	13	170.3	8.5	7.8
1985-86	63.8	47.1	13.4	26.2	150.4	5.1	2.7	10.8	170.7	8.7	12.7
1986-87	60.6	44.3	11.7	26.8	143.4	5.9	2.6	11.3	186.1	6.9	8.6
1987-88	56.9	46.2	11	26.4	140.4	5.8	3.5	12.7	196.7	6.4	6.8
1988-89	70.5	54.1	13.9	31.5	169.9	9.7	4.4	18	203	8.7	7.9
1989-90	74.1	49.7	12.6	34.3	170.6	8.1	4.1	16.8	222.6	11.4	8.4

* In bales; for cotton, 1 bale = 170 kg; for jute, 1 bale = 180 kg.

Source: Ministry of Agriculture, Directorate of Economics and statistics, 'Agricultural statistics at a glance'.

Table III 2.7

Yield of principal crops in India (kg/ha).

Agricultural year	Rice	Wheat	Pulses	Coarse grains	Food-grains	Ground nut	Rapeseed & mustard	Oilseed	Sugar cane	Cotton (lint)	Jute & mesta
1978-79	1328	1568	515	721	1022	835	525	570	49114	167	1186
1979-80	1074	1436	385	652	876	805	411	516	49358	160	1177
1980-81	1336	1630	473	695	1023	736	560	532	57844	152	1130
1981-82	1308	1691	483	733	1032	972	541	639	58359	166	1311
1982-83	1231	1816	519	685	1035	732	577	563	56441	163	1265
1983-84	1457	1843	548	813	1162	940	673	679	55978	141	1320
1984-85	1417	1870	526	795	1149	898	771	684	57673	196	1242
1985-86	1552	2046	547	664	1175	719	674	570	59889	197	1524
1986-87	1471	1916	506	675	1128	841	700	605	60444	169	1454
1987-88	1465	2002	515	721	1173	855	748	629	60006	168	1274
1988-89	1689	2244	598	814	1331	1132	906	824	60992	202	1540
1989-90	1756	2117	543	911	1349	929	826	729	65375	265	1656

Source: Ministry of Agriculture, Directorate of Economics and statistics, 'Agricultural statistics at a glance'.

Table III.2.8
Number and area of operational holdings (% distribution).

Size range (hectares)	No.of holdings			Area of holdings		
	1970/71	1980/81	1985/86	1970/71	1980/81	1985/86
Marginal Below 1	51	56.5	58	9	12.2	13.1
Small 1-2	18.9	18	18.2	11.9	14.1	15.5
Medium 2-10	26.2	23.1	21.8	48.2	50.9	50.9
Large 10 & above	3.9	2.4	2`	30.9	22.8	20.5

Source: Department of Economics & Statistics (Tata Services Ltd.), Statistical Outline of India, 1989-90, June 1989.

Cropped and irrigated area

The net sown area increased from 119.4 million hectares (mha) in 1951/52 to 140.1 mha in 1986/87, at an average growth rate of about 0.5% per annum. During the same time period, gross cropped area increased from 133.2 mha to 176.9 mha, at the rate of 0.8% per annum. The relatively faster growth of agricultural productivity was a result of a rise in irrigation facilities, which made multiple cropping possible on a larger portion of the cultivated land area. It may be noted, that during the 36 year time period 1951/52 to 1984/85, the shares of net and gross irrigated areas, to net sown and gross cropped areas respectively, also increased significantly.

Crops may be irrigated either through surface water sources (canals, rivers, ponds etc.) or by pumping ground water. Since the fifties, there has been a sharp increase in the share of land area irrigated by lifting ground water. This may be due not only to the fact that the Rural Electrification Corporation (REC) has made a concerted effort to energize pumpsets in rural areas, but also because the gestation lag of lift irrigation schemes are much smaller than those of large surface irrigation schemes. Furthermore, farmers may also prefer pumpsets, because of their relatively higher reliability -- because water becomes available when needed. In fact, owing to insufficient electricity supplies, certain farmers have also installed diesel pumpsets for standby use.

Owing to an increase in assured irrigation supplies, the cultivation of high yielding variety (HYV) crops has become possible. The yield of HYV crops is very sensitive to water and fertilizer inputs. In 1988/89, about 61% of gross cropped area of rice was under HYV; the corresponding figures for wheat were 84%, for jowar 41%, for bajra 49%,

and for maize 41%.

Table III. 2.9

Gross and net cropped and irrigated area (mha).

Year	Net sown area	Gross sown area	Area sown more than once	Net irrigated area	Gross irrigated area	Area irrigated more than once
1950-51	118.75	131.89	13.14	20.85	22.56	1.71
1955-56	129.16	147.31	18.15	22.76	25.64	2.88
1960-61	133.2	152.77	19.57	24.66	27.98	3.32
1965-66	136.2	155.28	19.08	26.34	30.9	4.56
1970-71	140.27	165.79	25.52	31.1	38.19	7.09
1975-76	141.65	171.29	29.64	34.59	43.36	8.77
1980-81	140.01	172.64	32.63	38.72	49.78	11.06
1981-82[P]	142.12	177.1	34.98	40.03	51.61	11.58
1982-83[P]	140.81	173.77	32.96	40.68	51.97	11.29
1983-84[P]	143.21	180.77	37.56	42.11	54.17	12.06
1984-85[P]	140.9	176.41	35.51	42.01	54.67	12.66
1985-86[P]	140.92	178.83	37.91	42.08	54.65	12.57
1986-87[P]	140.02	176.66	36.64	42.49	55.69	13.2
1987-88[P]	136.18	172.88	36.7	43.05	56.22	13.17

Note: 1. Figures are not strictly comparable over time due to change in coverage, concepts and definition.

2. Data released earlier have undergone partial revision owing to late receipt of further information from states.

Source: Ministry of Agriculture, Directorate of Economics and statistics, "Agricultural statistics at a glance".

Table III.2.10

Net irrigated area by sources of irrigation. ('000 hectares)

	Government canals	Private canals	Tanks	Tube wells	Other wells	Other sources	Total
1950/51	7158	1137	3613	-	5978	2967	20853
1960/61	9170	1200	4561	135	7155	2440	24661
1970/71	11972	866	4112	4461	7426	2266	31103
1978/79	14270	838	3918	8178	8232	2525	37961
1982/83	14875	495	3112	10684	8428	2375	39969
1983/84	15745	495	3783	10973	8548	2411	41955
1984/85	15366	495	3330	19265	8723	2600	41779
1985/86	15391	488	3070	11544	8621	2646	41760
1986/87	15548	479	2965	12275	8552	2667	42486
1987/88*	14990	484	2806	13156	8661	2951	43048

* Provisional.

Source: The Fertilizer Association of India, Fertilizer Statistics, New Delhi, 1990-91.

Table III.2.11

Area under irrigation -- cropwise. ('000 hectares).

	1970/71	1978/79	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88*
All crops	**38550**	**48090**	**52029**	**53937**	**54064**	**53978**	**55636**	**56216**
Rice	14917	16847	16073	17430	17662	17290	17843	16973
Wheat	9829	14770	17066	17886	17440	17312	17876	17890
Jowar	626	572	609	648	655	743	761	782
Bajra	514	424	661	560	552	574	646	733
Maize	925	901	1216	977	953	1020	1233	1199
Others	11739	14476	16404	16436	16802	17039	17277	18639

* Provisional.

Source: The Fertilizer Association of India, Fertilizer Statistics, New Delhi, 1990-91.

Table III.2.12
Area under HYV crops.

	1970/71	1980/81	1985/86	1987/88	1988/89	1989/90	1990/91*	1991/92@
Paddy								
Area under HYV ('000 hectares)	5588	18234	23494	22250	25407	26162	28057	29782
As a % of gross cropped area	14.9	45.4	57.1	57.3	60.7	62.0	--	--
Wheat								
Area under HYV ('000 hectares)	6480	16104	19075	19692	20175	20293	20411	21934
As a % of gross cropped area	35.5	72.3	82.9	85.4	83.7	86.5	--	--
Jowar								
Area under HYV ('000 hectares)	802	3500	6082	5960	6113	6869	6696	7669
As a % of gross cropped area	4.6	22.1	38.5	37.3	41.2	45.9	--	--
Bajra								
Area under HYV ('000 hectares)	205	3600	4992	3954	5865	5585	5146	6058
As a % of gross cropped area	1.6	30.9	46 7	45.4	48.7	51.3	--	--
Maize								
Area under HYV ('000 hectares)	462	1601	1799	2147	2445	2256	2579	2848
As a % of gross cropped area	7 9	26 7	30 6	38 6	41 2	38 5	--	--

* Anticipated achievement.
Target
Source The Fertilizer Association of India, Fertilizer Statistics, New Delhi, 1990-91

Irrigation requirements

Irrigation water requirements depend on the type of crop, the type of soil, evaporation rate and so on. For cultivating non-rice crops in any particular agro-climatic zone in India, it has been observed that although the required frequency and depth of irrigation may vary significantly from one cereal crop to another, the total water requirement during the entire cropping season varies only within a fairly narrow range. Water requirements for rice cultivation however, are considerably higher -- about 120 cu.m/ha/day on clayey soils and about 180 cu.m/ha/day on loamy soils; this difference is due largely to the higher percolation losses in the latter type of soil.

It follows that total water requirements in a particular season will depend on whether the crop grown is rice or not. However, in actual practice, if rice is to be grown

in one of the seasons, it is cultivated on a reduced field area, so that water requirements can be met. Therefore, it is reasonable to assume that in a given location, the choice of crop is not usually determined by the availability of water.

There are several factors, including the quality of seeds, the type of soil, climate and so forth, which effect the choice of crop and crop yield. However, it is observed that by and large, in all states in India, crop yields have risen with the availability of irrigation water. As a result, crop irrigation has been promoted by the Central and State Governments. For reasons mentioned in the previous section, ground water irrigation has grown faster than surface irrigation. About 68% of the potential ground water sources were exploited by 1984/85.

Among the various lift irrigation devices, the number of electric pumpsets has increased most rapidly. This is a direct outcome of the concerted drive undertaken by the REC to extend the grid to rural areas, so that electricity is available for agricultural purposes. The number of diesel pumpsets has also increased, although relatively slowly. A certain (unknown) fraction of the diesel pumpsets are installed in rural areas which are already electrified. Other diesel pumpsets are installed for lift irrigation in areas where the utility's electric grid has still not been extended. While the population of mechanized pumping devices has increased, that of the animal powered water lifts has reduced. This is largely because the water draw-down through the use of electric and diesel pumpsets is so much, that non-mechanized pumps can not be used effectively.

Table III 2.13 Cropping pattern all-India (1986-87 and 1987-88).

Crop	Area (thousand hectares)		Percentage of area to gross cropped area	
	1986-87	1987-88	1986-87	1987-88
Rice	41169	38944	23.3	22.5
Wheat	23315	23372	13.2	13.5
Jowar	16193	16523	9.2	9.6
Bajra	11502	9467	6.5	5.5
Maize	5925	5604	3.3	3.2
Ragi	2394	2243	1.3	1.3
Barley	1232	1146	0.7	0.7
Other cereals	3027	2968	1.7	1.7
Coarse cereals	40273	37951	22.8	19.5
Total cereals	**104757**	**100267**	**59.2**	**58**
Gram	7028	5835	4	3.4
Tur	3180	3303	1.8	1.9
Other pulses	13199	12563	7.5	7.3
Total pulses	**23407**	**21701**	**13.3**	**12.6**
Total foodgrains	**128164**	**121968**	**72.5**	**70.7**
Sugarcane	3202	3391	1.8	2
Condiments and spices	2204	2415	1.2	1.4
Total fruits	**2306**	**2347**	**1.3**	**1.4**
Potatoes	840	897	0.5	0.5
Onions	266	284	0.2	0.2
Total vegetable	**3509**	**3619**	**2**	**2.1**
Groundnut	7009	7556	4	4.4
Rapeseed and mustard	3047	3812	1.7	2.2
Sesamum	1837	1895	1	1.1
Linseed	1023	1035	0.6	0.6
Other oilseeds	2609	3595	3.4	4.2
Total oilseeds	**18840**	**21554**	**10.7**	**12.5**
Cotton	7031	7190	4	4.2
Jute	809	706	0.5	0.4
Mesta	265	261	0.2	0.2
Total fibres	**8228**	**8258**	**4.7**	**4.8**
Tobacco	406	366	0.2	0.2
Other crops	9797	8963	5.6	5.2
Gross cropped area	176656	172881	100	100

Source: Ministry of Agriculture, Directorate of Economics and statistics,

Table III.2.14

Seasonal water requirements of non rice crops* (cubic metre per hectare of sown area).

	Kharif (July-Oct.)	**Rabi (Nov.-March)**	**Hot weather (March-June)**
a. Sub-tropical zone			
a1 Hot, arid	5000-6000	4000-5000	8000-9000
a2 Hot, sub-humid	4500-5500	4000-5000	6000-7000
b. Tropical zone			
b1 Hot, sub-humid,humid	4500-5500	5000-6000	6500-7500
b2 Hot, semi-arid	6000-7000	6000-7000	9000-10000
b3 Hot, arid	9000-10000	8000-9000	12000-14000

* Assuming 70% irrigation application efficiency, which is the ratio between water available to the crop, and that delivered by the pump.

a1 Includes Punjab, Haryana and Uttar Pradesh.

a2 Incudes Assam, Orissa and West Bengal.

b1 Includes Tamil Nadu, Kerala and parts of Karnataka and Andhra Pradesh.

b2 Includes Maharashtra and parts of Karnataka, Gujarat, Andhra Pradesh and Madhya Pradesh,

b3 Includes Rajasthan and parts of Gujarat and Madhya Pradesh.

Source: C. Dakshinamurti, Water Resources of India and their utilization in Agriculture, Water Technology Centre, Indian Agriculture Research Institute, New Delhi, 1973.

Table III.2.15
Yield differential due to irrigation.

	Yield* (quintals/hectare)		% yield
	Irrigated land	**Unirrigated land**	
Andhra Pradesh	18.6	6.1	205
Bihar	10.9	8.0	36
Gujarat	10.9	6.9	174
Karnataka	23.3	6.3	270
Madhya Pradesh	12.9	7.1	82
Maharashtra	24.5	5.9	315
Punjab	23.6	10.6	123
Rajasthan	13.6	4.5	202
Tamil Nadu	23.1	8.1	185
Uttar Pradesh	20.4	8.6	137

* These are only macro-level data. Farm level variations are therefore missing. Besides, associated relevant information on the use of fertilizers, HYV seeds, etc. is not documented.
Source: B.D. Dhawan, Productivity Impact of Irrigation in India, Institute of Economic Growth, Sept. 1983.

Table III. 2.16

Planwise irrigation potential created & utilisation in India.

Period	Major & medium irrigation surface water		Minor irrigation						Irrigation (major, medium &K6 minor)	
			Surface water		Ground water		Total			
	P*	U**	P	U	P	U	P	U	P	U
Pre-plan up to 1951	9705	9705	6401	6401	6500	6500	12901	12901	22606	22606
First Plan (1951-56)	2486	1280	53	53	1777	1777	1830	1830	6459	5177
Second Plan (1956-61)	2143	2067								
Third Plan (1961-66)	2231	2123	58	58	4231	4231	4289	4289	8050	7988
Annual Plans (1966-69)	1530	1576								
Fourth Plan (1969-74)	2608	1937	450	450	3930	3930	4380	4380	6988	6317
Fifth Plan (1974-78)	4014	2475	538	538	3362	3362	3900	3900	7914	6375
Annual Plans (1978-80)	1895	1482	500	500	2220	2200	2700	2700	4595	4182
Sixth Plan (1980-85)	3401	2685	1697	1010	5823	4238	7520	5248	10921	7933
Pre-Plan + Plan Period	30013	25330	9697	9010	27823	26238	37520	35248	67533	60578
Seventh Plan* (1985-90)	4297	3906	1507	1211	7078	5790	8585	7001	12882	10907

* Potential created.

** Utilization.

Sources: [1] Central Water Commision (P&P Directorate).

[2] Ministry of Water Resources (minor irrigation division).

Table III.2.17

Population of lift irrigation devices ('000).

	Electric pumpsets	**Diesel pumpsets**	**Animal powered water lifts**
1950/51	21	66	3778
1960/61	200	230	4141
1968/69	1090	720	4675
1973/74	2430	1750	3682
1977/78	3300	2350	3505
1979/80	3950	2650	3326
1983/84	5309	3101	N.A.
1984/85	5708	N.A.	N.A.
1985/86	6152	N.A.	N.A.
1986/87	6656	N.A.	N.A.
1987/88	7225	N.A.	N.A.
1988/89	7819	N.A.	N.A.
1989/90	8350	N.A.	N.A.
1990/91	8818	N.A.	N.A.

Source: [1] T.G.K. Charlu and D.K. Dutt, Ground Water Development in India, Rural Electrification Corporation, New Delhi, 1982; and
[2] CMIE, Current Energy Scene in India, October, 1991.

Table III.2.18

Population of electric pumpsets ('000).

	1990/91*
Major states	
Andhra Pradesh	1213
Assam	4
Bihar	256
Gujarat	468
Haryana	361
Karnataka	744
Kerala	226
Madhya Pradesh	903
Maharashtra	1627
Orissa	54
Punjab	610
Rajasthan	392
Tamil Nadu	1325
Uttar Pradesh	655
West Bengal	90
Other states[a]	**11**
Union territories[b]	**33**
All-India	**8972**

[a] The other states include Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Nagaland and Tripura.

[b] The Union Territories include Andaman & Nicobar Islands, Chandigarh, Dadra & Nagar Haveli, Delhi, Goa, Daman & Diu, Lakshadweep and Pondicherry.

* As on 30 July, 1991.

Source: [1] CEA, Public Electricity, All India Statistics, General Reveiw; and [2] CMIE, Current Energy Scene in India, October 1991.

Land preparation and other equipment

Although there is no coherent farm mechanization policy, the population of mechanized pumpsets has increased rapidly, and so have the number of tractors and other mechanical equipment.

Both diesel powered tractors and bullock power are used for land preparation. The number of draught animals has grown very marginally since the early sixties, and the

number of bullock powered plough shares increased gradually from about 40.6 millic in 1961 to 47.5 million in 1977. However, the population of mechanized land preparatic equipment (agricultural tractors, power tillers and crawler tractors) grew rapidly durir this period. Similar trends may also be observed for equipment used for harvestin threshing and so on.

Table III.2.19

Population of mechanical devices ('000).

	1972	1977	1982
Agricultural tractors (=< 35 hp)	97.2	187.2	518.5
Agricultural tractors (36-50 hp)	37.5	70.1	
Agricultural tractors (> 50 hp)	9.8	17.9	
Power tillers	16.0	79.7	17.2
Crawler tractors (=< 75 hp)	15.2	16.3	-
Crawler tractors (> 75 hp)	3.2	3.7	-
Threshers	484.1	1025.0	205.8
Maize shellers	18.5	33.9	15.7
Harvester combine	4.3	-	7.7
Self propelled	-	27.5	-
Tractor propelled	-	13.1	-
Power operated chaff cutters	202.5	372.4	141.6
Other power operated equipment	33.5	44.7	-

Source: Ministry of Agriculture (G.O.I.), Indian Livestock Census 1982, New Delhi, 1989.

Table III.2.20

Population of non-mechanical devices ('000).

	1951	1956	1961	1966	1972	1977	1982
Wooden ploughs	51796	36142	38372	38923	39294	41031	40226
Iron ploughs	931	1376	2298	3523	5359	6516	6628
Carts	9862	10968	12072	12697	12960	12670	12924
Sugarcane crushers worked by bullock	505	545	490	615	678	669	684

Source: Central Statistical Organization, Department of Statistics, Statistical Abstract, India, 1987.

Energy consumption

Direct commercial energy inputs in agriculture are largely for two activities -- mechanized land preparation, and mechanized lift irrigation -- although commercial energy is also required for harvesting, threshing, drying and winnowing. As the use of commercial energy usually substitutes some form of human and/or animal energy, it is not correct to correlate direct commercial energy use with agricultural productivity. This observation may be validated further by noting that reliable irrigation facilities increase agricultural output in three ways: (i) by encouraging the use of high yielding varieties and inorganic fertilizers; (ii) by increasing the gross cropped area by making double/multiple cropping possible; and (iii) by bringing about a change in the cropping patterns.

Little information is available on the direct and indirect energy use. The singular exception is that of electricity sales, annual time- series data for which are available at the state level. Data on average capacity ratings of electric pumpsets and their annual utilization patterns are also estimated and published. However, corresponding data for diesel pumpsets are not available.

The problem in estimating the utilization of diesel pumpsets is compounded further, because some (an unknown fraction) are used for standby purposes even by farmers who have an electric pumpset, while others are used by farmers in non-electrified rural areas. And even the total diesel consumption for ground-water irrigation and land preparation is also not easily determined from published data (Annual Petroleum and Petrochemical Statistics, GOI), because only a fraction of diesel sales for agricultural purposes are listed under a separate heading (Plantation/Food, including food processing), while an (unknown) fraction is clubbed together with transport. However, some norms for diesel consumption in, and annual hours of usage of diesel pumpsets, and various types of tractors, are estimated.

Indirect energy use through fertilizers is also not easy to estimate, because information on the use of only inorganic fertilizers is documented. The use of organic manure may at best be estimated only on the basis of norms derived from isolated sample surveys.

Table III.2.21

Production, import and sale of power tillers.

Year	Indigenous production	Import	Total	Sales
1970-71	1387	70	1457	-
1980-81	2125	-	2125	1991
1981-82	2352	-	2352	2329
1982-83	2248	-	2248	2221
1983-84	2754	-	2754	2901
1984-85	4219	-	4219	4222
1985-86	3706	-	3706	3754
1986-87	3325	-	3325	3209
1987-88	3005	-	3005	3097
1988-89	4798	-	4798	4678

Source: Ministry of Agriculture, Directorate of Economics & Statistics "Indian agriculture in brief" - 23rd edition.

Table III 2.22

Production, import and sale of tractors - all India.

Year	Production		Total	Import	Total	Sales
	Organised	Small scale				
1970-71	20099	5	20104	13300	33404	-
1980-81	69932	75	70007	-	70007	65101
1981-82	84005	96	84101	-	84101	77386
1982-83	62943	111	63054	-	63054	63073
1983-84	76160	13	76173	-	76173	74318
1984-85	85003	2	85005	-	85005	80317
1985-86	-	-	75550	-	75550	76886
1986-87	-	-	80369	-	80369	80164
1987-88	-	-	92092	-	92092	93157
1988-89	-	-	109987	-	109987	110323

Source: Ministry of Agriculture, Directorate of Economics & Statistics "Indian agriculture in brief" - 23rd edition.

Table III 2.23

Estimated human labour use per hectare - Paddy (man Hrs)

Agricultural year	Andhra Pradesh	Assam	Bihar	Haryana	Karnataka	Madhya Pradesh	Orissa	Punjab	Tamil Nadu	Uttar Pradesh	West Bengal
1971-72	882.39	594.57	1027.29	-	-	-	897 38	-	1017 39	-	933 13
1980-81	1174.05	575.3	958 98	-	-	-	1020.86	-	1327.61	884 8	1004 44
1981-82	1121	645.04	777.84	-	1086.94	621 03	1033 66	857 55	1223.13	860 28	1204 48
1982-83	1233.27	678.6	829.86	-	1033.46	598 88	955 79	793.54	-	908.48	1091 25
1983-84	1290 3	676 06	867.29	-	1035.94	497 1	1036 72	853.19	-	876.62	1131 28
1984-85	-	603 41	-	672 71	1043.85	537 39	995 26	895.05	-	-	1183 53
1985-86	-	668 93	-	725 05	868 91	635.56	-	805 62	-	-	-
1986-87	-	615 78	-	699.63	857 54	576 2	1035.47	841 74	-	-	-
1987-88	-	-	-	754 23	-	-	-	809.06	-	-	-

Source Ministry of Agriculture, Directorate of Economics & Statistics "Cost of cultivation of principle crops in India"

Table III.2.24

Estimated organic manure application per hectare - Paddy (Qtl)

Agricultural year	Andhra Pradesh	Assam	Bihar	Haryana	Karnataka	Madhya Pradesh	Orissa	Punjab	Tamil Nadu	Utter Pradesh	West Bengal
1971-72	69 88	0 82	-	-	-	-	21 37		105 21	-	34 11
1980-81	55 96	0 86	9 55	-	-	-	25 17	-	38 83	42 85	18 14
1981-82	51 5	1 75	6 62	-	85 45	4 69	24 87	42 93	33 41	24 93	68 23
1982-83	71 21	2 44	5 24	-	45 6	5 62	26 23	68 74	-	31 99	32 93
1983-84	79 67	2 14	6 66	-	63 9	9 98	27 85	59 11	-	22 37	29 64
1984-85	-	1 65		12 35	100 92	12 65	22 79	85 35	-	-	26 98
1985-86	-	1 18	-	7 6	67 92	14 67	-	86 44	-	-	-
1986-87	-	1.67	-	6.7	74 01	19 18	28 74	71 06	-	-	-
1987-88	-	-	-	0 32	-			43 13	-		-

Source Ministry of Agriculture, Directorate of Economics & Statistics "Indian agriculture in brief" 23rd edition

Table III 2.25

Estimated animal labour use per hectare - Paddy (man Hrs).

Agricultural year	Andhra Pradesh	Assam	Bihar	Haryana	Karnataka	Madhya Pradesh	Orissa	Punjab	Tamil Nadu	Utter Pradesh	West Bengal
1971-72	157 17	239.67	-	-	-	-	248.59	-	255.27	-	223.35
1980-81	157 23	234 18	198 59	-	-	-	258.48	-	226.26	130.88	217 61
1981-82	145	256.41	276.55	-	171.07	157.17	274.81	36.54	205.82	143.6	242.56
1982-83	186 87	268 61	250 33	-	173 92	141.01	276.9	29.69	-	121 48	226 61
1983-84	170 85	269 74	246 3	-	164 73	148 6	286.48	26 69	-	115 58	231 38
1984-85	-	274.27	-	25 71	160 07	138 55	276.01	38 26	-	-	238 4
1985-86	-	265 42	-	37 93	116 16	158 45		30 57		-	-
1986-87	-	243 56	-	41 84	111 66	148 76	268 81	25 45	-	-	-
1987-88	-			34 93	-	-	-	18 96	-	-	-

Source Ministry of Agriculture, Directorate of Economics & Statistics "Cost of cultivation of principle crops in India"

Table III 2 26

Estimated inorganic fertilizer consumption per hectare - Paddy (kg nutrients)

Agricultural year	Andhra Pradesh	Assam	Bihar	Haryana	Karnataka	Madhya Pradesh	Orissa	Punjab	Tamil Nadu	Utter Pradesh	West Bengal
1971-72	57 02	0 07	-		-	-	9 82	-	65 57	-	16 73
1980-81	134 07	0 07	21 45	-	-	-	15 81	-	124 29	32 81	21 22
1981-82	122 24	0 11	21 44	-	72 99	21 72	9 22	171 72·	149 01	41 23	218 13
1982 83	119 14	0 02	24 51		83 88	20 13	15 75	157 57	-	45 72	29 46
1983 84	139 15	0 3	28 73	-	89 34	15 95	16 59	213 14	-	48 17	47 89
1984 85	-	0 47		128 34	97 4	16 27	29 26	192 57	-	-	28 57
1985-86	-	0 97	-	139 74	63 24	31 27	-	161 3	-	-	-
1986-87	-	1 6	-	118 56	76 73	30 81	37 04	165 87	-	-	-
1987-88	-	-		138 36	-	-	-	194 81		-	-

Source Ministry of Agriculture. Directorate of Economics and statistics, Deptt of Agriculture and cooperation - "Cost of cultivation of principal crops in India", GOI 1991

Table III 2.27

Estimated human labour use per hectare - wheat (man hrs).

Agricultural year	Haryana	Madhya Pradesh	Punjab	Rajasthan	Utter Pradesh
1970-71	-	330.49	-	-	-
1980-81	-	-	356.86	-	644.94
1981-82	407.54	362.39	383.92	594.26	627.82
1982-83	417.2	387.98	394.19	626.84	662.53
1983-84	402.97	344.56	408.45	595.37	633.53
1984-85	391.61	371.7	467.9	564.54	-
1985-86	382.37	355.84	437.08	559.75	571.88
1986-87	362.35	379.09	421.46	514.62	575.84
1987-88	379.79	-	397.91	-	-

Source: Ministry of Agriculture, Directorate of Economics and statistics, Deptt of Agriculture and cooperation - 'Cost of cultivation of principal crops in India', GOI 1991.

Table III 2.28

Estimated animal labour use per hectare - wheat (pair hrs).

Agricultural year	Haryana	Madhya Pradesh	Punjab	Rajasthan	Utter Pradesh
1970-71	-	157.29	-	-	-
1980-81	-	-	37.94	-	169.58
1981-82	67.68	131.24	31.49	179.44	161.73
1982-83	83.19	145.35	30.04	136.45	164.96
1983-84	69.13	129.74	27.89	108.51	148.59
1984-85	51.62	157.42	30.83	115.17	-
1985-86	50.19	134.31	24.78	106.5	117.9
1986-87	49.49	136.72	19.31	75.66	112.25
1987-88	46.95	-	15.58	-	-

Source: Ministry of Agriculture, Directorate of Economics and statistics, Deptt of Agriculture and cooperation - "Cost of cultivation of principal crops in India", GOI 1991.

Table III 2.29

Estimated organic fertilizer consumption per hectare - wheat (Qtl).

Agricultural year	Haryana	Madhya Pradesh	Punjab	Rajasthan	Utter Pradesh
1970-71	-	6.03	-	-	-
1980-81	-	-	3.4	-	4.57
1981-82	0.13	0.29	7.23	2.34	14.43
1982-83	3.97	0.96	13.41	2.6	18.38
1983-84	0	2.65	9.78	3.32	17.08
1984-85	0.87	2.17	14.47	3.52	-
1985-86	1.49	1.32	5.66	1.96	9.96
1986-87	0.43	0.73	7.16	2.62	6.93
1987-88	0.8	-	8.33	-	-

Source: Ministry of Agriculture, Directorate of Economics and statistics, Deptt of Agriculture and cooperation - "Cost of cultivation of principal crops in India", GOI 1991.

Table III 2.30

Estimated inorganic fertilizer consumption per hectare - wheat. (kg. nutrients).

Agricultural year	Haryana	Madhya Pradesh	Punjab	Rajasthan	Utter Pradesh
1970-71	-	2.32	-	-	-
1980-81	-	-	168.35	-	75.34
1981-82	90.06	28.21	153.05	5.44	88.27
1982-83	99.43	28.39	155.59	5.56	89.39
1983-84	118.15	28.84	161.24	5.05	95.02
1984-85	126.89	33.12	162.36	4.97	-
1985-86	144.5	31.68	167.82	5.18	103.75
1986-87	148.64	35.37	182.4	5.4	108.15
1987-88	139.64	-	183.2	-	-

Source: Ministry of Agriculture, Directorate of Economics and statistics, Deptt of Agriculture and cooperation - "Cost of cultivation of principal crops in India", GOI 1991.

Table III.2.31

Operation-wise energy requirements for various crops at different centres.

Energy requirements for various fields operations, MJ/ha

Crop	Centre	Farmers category	Seed-bed preparation	Sowing/ transp-lanting	Manuring/ fertilizer application	Weeding/in-tercultural operation	Irrigation	Plant prote-ction
Paddy	Kharagpur	Marginal	1541.26	445.50	91.34	323.99	20.72	9.02
		Small	1398.69	464.52	107.80	388.14	9.02	10.68
	Coimbatore	Small	3246.00	544.00	715.00	429.00	51750.00	4.00
		Medium	4341.00	594.00	428.00	511.00	-	118.00
	Jabalpur	Marginal	996.00	248.00	-	849.00	-	-
		Small	955.00	244.00	-	833.00	-	-
		Medium	911.00	223.00	-	784.00	-	-
		Large	1029.00	275.00	-	970.00	-	-
		Tractor	1968 00	673.00	-	1226 00	-	-
	Pantnagar	Marginal	1573.90	474.90	130.80	321 90	1513 10	0 80
		Small	1681.90	895.50	139 50	555.90	2721.20	-
		Medium	1996.50	762.30	32.30	569 40	3701.60	-
		Large	2644.10	648 80	78 10	344 80	2802 30	-
Wheat	Jabalpur	Marginal	967 00	386 00	-	-	-	186.00
		Small	941 00	302 00	-	-	-	217 00
		Medium	923 00	342 00	-	-	927 00	225 00
		Large	953.00	426 00	-	-	1506 00	265 00
		Tractor	1035.00	617 00	-	-	1784.00	285 00
	Pantnagar	Marginal	2439.50	402.20	97.40	103.50	1733 40	-
		Small	1998.10	370.40	79.30	135.40	1946.90	-
		Medium	3504.80	421 20	87.70	153 00	2184 40	-
		Large	1261.50	317.80	102.20	194.10	6226.50	-
Maize	Coimbatore	Small	1708.00	223.00	1314 00	942 00	7357 00	1367 0
		Medium	1492.00	207 00	437 00	866 00	9157.00	1150 0
	Patnagar	Marginal	1837 40	419 30	460 80	745 10	375 10	-
		Small	1548 90	814 50	187 30	506.40	632.40	-
		Medium	1709.30	253 40	96.50	539.20	836 50	-
		Large	1343 50	315 30	95 30	539 10	308 20	-
Soyabean	Jabalpur	Marginal	724 00	386 00	-	482 00	-	245 00
		Small	702 00	364 00	-	509 00	-	246 00
		Medium	754 00	364 00	-	544 00	-	272 00
		Large	792 00	399 00	-	599 00	-	286 00
Groundnut	Coimbatore	Small	1482.00	686 00	824 00	1270 00	14271 00	442 00
		Medium	1848.00	733.00	565.00	1184 00	11320 00	495 00
Jowar	Jabalpur	Marginal	806 00	294.00	-	958.00	-	380.00
		Small	771.00	239.00	-	892.00	-	411 00
		Medium	827 00	304.00	-	889 00	-	441 00
		Large	846.00	343 00	-	872 00	-	462 00
Bajra	Pantnagar	Marginal	1221.80	315 10	75 30	219 70	87.60	-
		Small	1257 60	296 20	49.80	313 20	113 60	-
		Medium	1653 70	311 20	127 40	310.80	-	-
		Large	2041 20	342 30	38 00	341 00	232 40	-
Potato	Kharagpur	Marginal	4084 08	516 29	82 36	674 39	1594198	657 55
		Small	3476 07	507 95	80 08	746 47	15789 77	651 91
		Medium	4071 90	525 13	64 68	792 91	16885 30	670 10
		Large	1458 49	237 14	33.01	370 24	1563 75	326 81
Gram	Jabalpur	Marginal	706 00	256.00	-	-	-	176 00
		Small	724 00	245 00	-	-	-	167 00
		Medium	742.00	203.00	-	-	-	178 00
		Large	765.00	227 00	-	-	-	208.00
		Tractor	681.00	543.00	-	-	-	235 00

Source: ICAR, Research Digest on Energy Requirements in Agricultural Sector (1971-1982).

Crop	Centre	Farmers category	Harvesting	Threshing	Transportation	Miscelleneous	Total energy	Yield, t/ha	Specific energy MJ/t
Paddy	Kharagpur	Marginal	319.39	309.36	560.91	71.54	3693.03	3.06	1206.87
		Small	324.76	318.08	1093.47	11.70	4126.86	3.29	1254.36
	Coimbatore	Small	1267.00	-	-	17274.00	75229.00	5.11	14721.9
		Medium	1184.00	-	-	51750.00	58926.00	6.28	9383.12
	Jabalpur	Marginal	373.00	497.00	-	74.00	3037.00	1.30	2336.15
		Small	366.00	512.00	-	92.00	3002.00	1.33	2257.14
		Medium	382.00	539.00	-	95.00	2934.00	1.36	2157.35
		Large	451.00	603.00	-	133.00	3461.00	1.59	2176.73
		Tractor	588.00	1068.00	-	167.00	5690.00	1.75	3251.43
	Pantnagar	Marginal	-	-	30.70	459.60	4505.70	-	-
		Small	-	-	46.50	568.20	6608.70	-	-
		Medium	-	-	38.10	599.90	7700.10	-	-
		Large	-	-	30.30	489.50	7037.90	-	-
Wheat	Jabalpur	Marginal	536.00	-	-	34.00	2109.00	1.05	2008.57
		Small	508.00	-	-	196.00	2164.00	1.20	1803.33
		Medium	831.00	-	-	40.00	3288.00	1.67	1968.86
		Large	1000.00	-	-	42.00	4192.00	2.00	2096.00
		Tractor	1301.00	-	-	52.00	5074.00	2.67	1900.37
	Pantnagar	Marginal	-	39 10	-	1226.70	6041 80	-	-
		Small	-	793.50	-	1146.50	6470.10	-	-
		Medium	-	70.20	-	5240.70	11662.00	-	-
		Large	-	53.90	-	868.30	9024.30	-	-
Maize	Coimbatore	Small	-	-	-	0.00	12911.00	2.50	5164.4
		Medium	-	-	-	0.00	13309.00	1.86	7155.3
	Patnagar	Marginal	-	40.00	209.00	694.10	4780.80	-	-
		Small	-	34.00	227.90	60.20	3891 20	-	-
		Medium	-	129.40	5.80	485.80	4055.90	-	-
		Large	-	16.40	-	468.50	3086.30	-	-
Soybean	Jabalpur	Marginal	531.00	-	32.00	2400.00	0.75	3200.00	-
		Small	578.00	-	85.00	2484.00	0.70	3548.57	-
		Medium	519.00	-	37.00	2490.00	0.78	3192.31	-
		Large	709.00	-	45.00	2830.00	0.87	3252.87	-
Groundnut	Coimbatore	Small	-	-	0.00	18975.00	3.40	5580.88	-
		Medium	-	-	42.00	16187.00	2.81	5760.50	-
Jowar	Jabalpur	Marginal	251.00	-	52.00	2741.00	1.00	2741.00	-
		Small	324.00	-	38.00	2675.00	1.18	2266.95	-
		Medium	350.00	-	42 00	2853.00	1 23	2319.51	-
		Large	420 00	-	46.00	2989.00	1.45	2061.38	-
Bajra	Pantnagar	Marginal	-	107.90	736.60	2764.00	-	-	-
		Small	-	49.70	594.50	2674.60	-	-	-
		Medium	-	43 10	654.50	3100.70	-	-	-
		Large	-	389 50	763.70	4148 10	-	-	-
Potato	Kharagpur	Marginal	-	-	476.34	22432.99	4.31	5204.68	-
		Small	-	-	552.12	21804.37	5.57	3914.61	-
		Medium	-	-	595.93	23605.95	5.94	3974.07	-
		Large	-	-	14269.38	18258.82	2.96	6168.52	-
Gram	Jabalpur	Marginal	386.00	30.00	-	0.00	1554.00	0.60	2588.3
		Small	380 00	37.00	-	-	1489.00	0.59	2523.7
		Medium	447.00	35.00	-	45.00	1650.00	0.70	2357 1
		Large	365.00	33.00	-	0.00	1598.00	0.75	2126.0
		Tractor	386.00	-	41.00	11.00	1897.00	0.81	2341.9

Table III.2.32

Source-wise energy requirements for various crops at different centres.

Crop	Centre	Farmers category	Animate energy, MJ/ha inanimate energy, MJ/ha				
			Human	Bullock	Elec. diesel/ petrol	Indirect energy like seed, fertilizers & machinery	Total energy, MJ/ha
Paddy	Kharagpur	Marginal	2727.00	1921.00		107.00	4755.00
			(57.4)	(40.4)		(2.2)	(100.0)
		Small	2855.00	2168.00		132.00	5155.00
			(55.4)	(42.1)		(2.5)	(100.0)
		Medium	2673.00	1809.00		127.00	4609.00
			(58.0)	(39.2)		(2.8)	(100.0)
		Large	2484.00	1332.00		81.00	3897.00
			(63.7)	(34.2)		(2.1)	(100.0)
	Jabalpur	Marginal	169.00	1345.00		1837.00	4874.00
			(34.7)	(27.6)		(37.7)	(100.0)
		Small	16472.00	1359.00		1840.00	4841.00
			(33.9)	(28.1)		(38.0)	(100.0)
		Medium	1612.00	1322.00		1840.00	4774 00
			(33.8)	(27.7)		(38.5)	(100.0)
		Large	1948.00	1513.00		2515.00	5976.00
			(32.6)	(25.3)		(42.1)	(100.0)
		Tractor	2089 00	-	3601.00	2870.00	8560.00
			(24.4)		(42.1)	(33.5)	(100.0)
	Coimbatore	Marginal	3188.00	2750.00	66250 00		72188.00
			(4.4)	(3.8)	(91.8)		(100.0)
		Small	3167 00	2960 00	69102.00		75229 00
			(4.2)	(3.9)	(91.9)		(100.0)
		Medium	2966.00	3760.00	52200.00		58926.00
			(5.0)	(6.4)	(88.6)		(100 0)
Wheat	Jabalpur	Marginal	511.00	1133.00	466.00	2343.00	4453.00
			(11.5)	(25.4)	(10.5)	(52.6)	(100.0)
		Small	541.00	1090.00	532.00	2493.00	4656.00
			(11.6)	(23.4)	(11.4)	(53.6)	(100.0)
		Medium	599.00	1059.00	1629 00	2733.00	6020.00
			(10.0)	(11.76)	(27.1)	(45.4)	(100.0)
		Large	707.00	1153.00	2330.00	2853 00	7043.00
			(10.0)	(16.4)	(33 1)	(40.5)	(100.0)
		Tractor	538.00	-	4535.00	3563.00	8636.00
			(6.2)		(52.5)	(41.3)	(100.0)
Maize	Coimbatore	Small	3269.00	2100.00	342.00	7200.00	12911.00
			(25.3)	(16.33)	(2 6)	(55.8)	(100.0)
		Medium	22684.00	1400.00	225.00	9000.00	13309.00
			(20.2)	(10.5)	(1.7)	(67.6)	(100.0)

contd...

Table III.2.32 (contd.)

Crop	Centre	Farmers category	Animate energy, MJ/ha inanimate energy, MJ/ha Human	Bullock	Elec. diesel/ petrol	Indirect energy like seed, fertilizers & machinery	Total energy MJ/ha
Jowar	Jabalpur	Marginal	1060.00	1503.00	177.00	183.00	2923.00
			(36.3)	(51.4)	(6.1)	(6.2)	(100.0)
		Small	1047.00	1383.00	244.00	283.00	2957.00
			(35.4)	(46.8)	(8.3)	(9.5)	(100.0)
		Medium	1077.00	1502.00	272.00	183.00	3034.00
			(35.5)	(49.5)	(9.0)	(6.0)	(100.0)
		Large	1154.00	1501.00	332.00	483.00	3470.00
			(33.3)	(43.3)	(9.6)	(13.0)	(100.0)
		Tractor	98.00	-	2865.00	563.00	3526.00
			(2.7)		(81.3)	(16.0)	(100.0)
Groundnut	Coimbatore	Small	2650.00	2240.00	14085.00	-	18975.00
			(14.0)	(11.8)	(74.2)		(100.0)
		Medium	2611.00	25.60	11016.00	-	16187.00
			(16.1)	(15 8)	(68.1)		
Potato	Kharagpur	Marginal	4312.00	3190.00	14483.00	447.00	22432.00
			(19.2)	(14.2)	(64.6)	(2.0)	(100.0)
		Small	3993.00	2431.00	14924.00	456.00	21804.00
			(18.3)	(11.1)	(68.4)	(2 2)	(100.0)
		Medium	4237.00	2253.00	16598.00	518.00	23606.00
			(17.9)	(9.5)	(70.3)	(2.3)	(100.0)
		Large	2106.00	710.00	15053.00	390.00	18259.00
			(11.5)	(9.3)	(82.4)	(2.2)	(100.0)
Sugarcane	Coimbatore	Small	8987.00	1820.00	66225.00	-	77032.00
			(11.7)	(2.3)	(86.0)		(100.0)
		Medium	8246.00	2080.00	72180.00	-	82506.00
			(10.0)	(2.5)	(87.5)		(100.0)

Source: ICAR, Research Digest on Energy Requirements in Agricultural Sector (1971-1982).

Table III.2.33
Normative data for diesel pumpsets and land preparation equipment.

Diesel pumpset	
Average capacity	7 hp
Diesel cons. rate	0.2 kg of HSD per BHP - hour
Annual usage	1000 hours
Land preparation equipment	
Agricultural tractors	
- average rating	30 hp
- diesel cons. rate	2.7 litres/hour
- annual usage	1000 hours
Power tillers	
- average rating	8.5 hp
- diesel cons. rate	1.25 litres/hour
- annual usage	1000 hours
Crawler tractors	
- average rating	65 hp
- diesel cons. rate	6.5 litres/hour
- annual usage	1000 hours

Source: Advisory Board on Energy (GOI), Towards a Perspective on Energy Demand and Supply in India in 2004/05, May 1985.

Table III.2.34
Use of electric pumpsets.

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86	1986/87	1987/88
No. of pumpsets energised ('000)	1629.4	2441.6	3029.2	3965.8	4973.3	6151.9	6656.5	7225.8
Connected load (MW)	6224.8	9494.2	12053.0	15247.4	18712.3	22591.2	24286.9	26105.0
Electricity cons.(GWh)	4470.23	6310.21	9620.63	13452.0	17816.84	23421.9	29443.9	35266.5
Average capacity of pumpsets (hp)	5.03	5.12	5.24	5.06	4.95	4.93	3.65	3.61
Electricity cons.per pumpset (kWh)	2743	2584	3176	3392	3640	3807	4423	4881
Electricity cons. per unit of connected load (kWh/kW)	718	665	798	882	952	1037	1212	1351

Source: CEA, Public Electricity Supply (All India Statistics): General Review, New Delhi, various issues.

Table III.2.35
Total diesel and electricity consumption.

	1970/71	1976/77	1979/80	1982/83	1984/85	1985/86	1986/87	1987/88
Electricity cons.(GWh)	4470.23	9620.63	13452.0	17816.84	21400	23532.45	28217.5	37604
Diesel cons.* ('000 tonnes)	N.A.	N.A.	N.A.	141	157	179	185	209

* Accounts for consumption of HSD and LDO in the Plantation/Food (including processing) sector.

Sources: [1] CEA, Public Electricity Supply, (All India Statistics), General Review, various issues;
[2] CMIE, Current Energy Scene in India, May 1990; and
[3] Ministry of Petroleum and Natural Gas, Indian Petroleum & Natural Gas Statistics, various issues.

Table III.2.35

All India consumption of NPK fertilizers. ('000 tonnes)

	Nitrogenous fertilizers	Phosphatic fertilizers	Potassic fertilizers	Total
1951/52	58.7	6.9	-	65.6
1955/56	107.5	13.0	10.3	130.8
1960/61	211.7	53.1	29.0	293.8
1965/66	574.8	132.5	77.3	784.6
1970/71	1479.3	541.0	236.3	2256.6
1975/76	2148.6	466.8	278.3	2893.7
1980/81	3678.1	1213.6	623.9	5515.6
1981/82	4068.7	1322.9	676.2	6067.8
1982/83	4242.5	1432.7	726.3	6401.4
1983/84	5204.4	1730.3	775.4	7710.1
1984/85	5486.1	1886.4	838.5	8211.0
1985/86	5660.8	2005.2	808.1	8474.1
1986/87	5772.7	2105.5	860.2	8738.4
1987/88	5716.8	2187.1	880.5	8784.3
1988/89	7257.1	2721.0	1068.4	11040.0
1989/90	7385.0	3014.0	1168.0	11568.2
1990/91*	8021.0	3172.2	1330.0	12523.5

* Provisional

Source: The Fertilizer Association of India, Fertilizer Statistics , New Delhi, 1990-91.

Industry

Introduction

Industry is a major energy consuming sector in India. However, the available data base is terribly inadequate and out-of-date. The most recent period for which data on industrial output, and energy and other inputs are available, in physical units, is 1983/84; these data are up to a 4-digit level of classification as per the SIC system. Summary results (for industries classified up to a 3-digit level as per the SIC system) are also available for 1987/88. These summary results, however, present all energy consumption data only in monetary terms. As energy prices vary from state to state, and at least for coal, from one part of a state to another, it becomes difficult to use such data meaningfully for analytical work.

Where time series data are available in physical units, the classification of industries for which coal consumption data are available, is not consistent with that for petroleum products or/and electric power consumption data. This makes it difficult to estimate energy consumption in various categories of industries, except at very aggregate levels of classification. Furthermore, consumption of fuelwood and charcoal -- which are used particularly in the unregistered manufacturing sector -- is not documented.

A simple analysis shows that the following manufacturing industries spend a very high portion of their value added on energy purchases : (i) non-metallic mineral products (SIC code : 32); (ii) basic metals and alloys (SIC : 33); (iii) chemicals and chemical products (SIC : 31); (iv) paper and paper products (SIC code : 28); and (v) cotton textiles (SIC Code : 23). These industrial categories are also likely to be more energy intensive than other manufacturing industries. Detailed data on some particular energy intensive manufacturing industries are presented in subsequent sections.

Table III.3.1(a)

Value added from manufacturing -- registered sector (Rs. million, 1980/81 prices).

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
Food products	8450	11160	15060	16790	16940	17760	17760	18540
Beverages, tobacco and tobacco products	2460	2610	2700	4970	4200	4200	4200	3620
Textiles	2466	2309	2256	2594	2571	2860	3153	3173
Wood & wood products	710	710	720	910	870	900	970	640
Paper & paper products	5260	5750	5300	6100	7160	6920	8340	8500
Leather, leather & fur products	770	940	1040	1260	1470	1470	1470	1530
Rubber, plastic, petroleum and coal products	6140	5770	8800	9300	10740	15750	15750	16410
Chemicals & chemical products (excluding coal & petroleum)	18540	22030	22810	28080	29190	30450	36460	41750
Non-metallic mineral products	4740	5080	6360	7220	9130	9700	9700	9560
Basic metal & alloy industries	15560	17350	16010	17360	17330	19060	19060	20380
Metal products and parts (excluding machinery, transport Equipment)	3630	3680	3720	4170	4450	4780	5160	5380
Machinery, machine tools and parts (excluding electrical machinery)	9850	10530	11270	12690	15360	15630	15630	15350
Electrical machinery, appliances and apparatus	9180	9430	12120	12760	16070	16070	16070	21150
Transport equipment & parts	10070	11400	12830	14010	15470	15470	17230	18060
Miscellaneous manufacturing industries	4560	5480	6770	7900	9450	11650	13230	14470
Repair services	1820	1820	2190	2510	2730	2590	2720	3720
Net value added	100500	108760	120790	140470	152910	165360	176350	188200
Consumption of fixed capital	22310	23520	24220	25820	27400	28930	30700	32700
Gross value added	**122810**	**132280**	**145010**	**166290**	**180310**	**194290**	**207050**	**220900**

Source: Central Statistical Organization, National Accounts Statistics, GOI, New Delhi, 1990.

Table III.3.1(b)

Value added from manufacturing -- unregistered sector (Rs. million, 1980/81 prices).

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
Food products	5210	5630	5270	6100	5960	6210	6320	6200
Beverages, tobacco and tobacco products	3220	3650	3710	3440	3650	3350	3620	2950
Textiles	28440	29560	30710	30420	33220	36240	36960	38920
Wood & wood products	9180	9400	8440	9050	7630	7550	7200	6210
Paper & paper products	2140	2090	2170	2610	2940	3230	3290	3400
Leather, leather & fur products	2330	2470	2460	2580	2690	2640	2700	2710
Rubber, plastic, petroleum and coal products	1000	1520	1300	1600	1950	1750	1550	1570
Chemicals & chemical products (excluding coal & petroleum)	1780	1930	2040	2080	2350	2650	2870	3590
Non-metallic mineral products	2930	3310	3370	3570	3390	3420	3480	4620
Basic metal & alloy industries	1310	1100	1140	1040	1400	1400	1550	1770
Metal products and parts (excluding machinery, transport equipment)	7830	8660	10220	10770	10800	9970	10820	10880
Machinery, machine tools and parts (excluding electrical machinery)	4390	4870	4910	5250	5600	5710	6220	6100
Electrical machinery, appliances and apparatus	1980	2050	2290	2820	2940	3970	5040	6630
Transport equipment & parts	5260	5680	5850	6490	6920	7140	7610	7980
Miscellaneous manufacturing industries	4860	7250	7520	5080	5960	7410	11430	13210
Repair services	13120	14210	14770	16790	16370	20280	23390	24690
Net value added	86480	93830	95810	98670	101280	109760	120300	126090
Consumption of fixed capital	7150	7710	8260	8810	9940	10140	10840	11580
Gross value added	**93630**	**101540**	**104070**	**107480**	**111220**	**119900**	**131140**	**137670**

Source: Central Statistical Organization, National Accounts Statistics, GOI, New Delhi, 1990

Table III.3.2

Production of selected industries.

	1970/71	1979/80	1982/83	1985/86	1987/88	1988/89	1989/90*
Metallurgical Industries							
Pig iron (million tonnes)	6.99	8.58	9.58	10.06	10.87	11.88	11.96
Finished steel (million tonnes)	4.64	6.90	8.05	9.55	10.49	10.87	13.00
Aluminium ('000 tonnes)	168.8	191.90	211.50	264.80	277.7	357.30	427.10
Blister copper ('000 tonnes)	9.3	22.5	35.8	33.6	33.9	44.80	42.50
Chemical & Allied Industries							
Nitrogenous fert. ('000 tonnes)	830	2226	3424	4328	5466	6712	6742
Phosphatic fert. ('000 tonnes)	229	757	980	1428	1665	2252	1792
Soda ash ('000 tonnes)	449	556	635	849	956	1191	1377
Caustic soda ('000 tonnes)	371	550	577	727	958	903	925
Paper & Paper board ('000 tonnes)	755	1058	1205	1517	1662	1726	1854
Cement (million tonnes)	14.3	18.6	27.1	33.1	39.6	44.3389	45.8
Textile industries						9081	
Jute textiles ('000 tonnes)	1060	1137	1338	1352	1192	1398	1304
Cotton cloth (million metres)	7602	7533	7953	9178	9400	2803	NA
Mixed/blended cloth (million metres)	170	1529	1293	1337	1339	1398	NA
Artificial fibres (million metres)	951	1366	1368	1983	2253	2803	NA
Food industries							
Sugar ('000 tonnes)	3740	3859	8232	7003	9110	8716	10829
Vanaspati ('000 tonnes)	558	618	886	870	980	996	939
Salt ('000 tonnes)	5568	6484	7823	10482	9827	8326	10598
Engineering industries							
Machine tools (million Rs.)	430	1652	2699	2914	3899	5107	6480
Automobiles ('000)	87.9	104.6	151.4	219.2	291.6	317.2	351.1
Power transformers (million KVA)	8.09	18.63	18.6	27.25	24.73	28.50	36.9
Electric motors (million HP)	**2.72**	**3.74**	**4.81**	**5.25**	**4.26**	**5.33**	**5.19**

* Provisional

Source: GOI, Economic Survey, various issues.

Table III.3.3

Energy consumption in industry.

	1970/71	1976/77	1982/83	1985/86	1986/87	1987/88	1988/89	1989/90
Electricity purchased from utilities (GWh)	29579.1	41605.6	53063.8	66980.1	71495.9	77104	76819	N.A.
Self generated electricity (GWh)	5347.2	7240.3	9989	12997.3	N.A.	13764	19881	N.A.
Total electricity cons. (GWh)	34926.3	48845.9	63052.8	79977.4	N.A.	90868	96700	N.A.
Fuel oils cons.[b] ('000 t)	N.A.	3641[c]	4304[d]	4702[d]	5125[d]	5007[d]	5439[d]	5749[d]
Naphtha cons. ('000 t)	N.A.	2183	2958	3106	3249	2852	3364	3350
HSD cons. ('000 t)	N.A.	610[e]	876	1263	1293	1500	1353	1594
LDO cons. ('000 t)	N.A.	877[e]	302	397	433	520	604	609
LPG cons. ('000 t)	N.A.	52	70[f]	140[g]	144[g]	243[g]	326[g]	272[g]
Coal cons.[h] (million t)	N.A.	55.8	67.3	75.07	78.13	78.12	77.32	75.63

[b] Furnace oil, LSHS and HHS. Excludes fuel oils used for power generation.

[c] Includes consumption of DGS&D.

[d] Excludes consumption of DGS&D.

[e] Includes HSD/LDO used for power generation, plantation/food processing, agriculture retail trade and DGS&D sectors.

[f] Includes LPG used in commercial sector only.

[g] Includes LPG used in commercial sector too.

[h] Includes coal used for making hard coke, but which is not used in the steel industry.

Sources: [1] CEA, Public Electricity Supply (All India Statistics): General Review, New Delhi, various issues;
[2] Department of Petroleum, Indian Petroleum & Petrochemical Statistics, New Delhi, various issues;
[3] Coal controllers organization, All India Annual Coal Statistics, various issues, GOI, Calcutta; and
[4] CMIE, Current Energy Scene in India, July 1989.

Table III.3.4

Manufacturing industry's expenditure on fuel in 1987/88.

SIC code	Manufacturing industry	Rs. million			Fuel/Op (%)	Fuel/VA (%)
		Fuel consumption	Value of Op	Net VA		
32	Non-metallic minerals	12904	52741	11134	24.5	115.9
33	Basic metals	23415	177724	25710	13.2	91.1
28	Paper	4792	43098	8635	11.1	55.5
31	Chemicals	23030	205678	37368	11.2	61.6
23	Cotton textiles	8146	81906	15430	9.9	52.8
24	Wool, silk textiles	3870	54454	8818	7.1	43.9
25	Jute, hemp	696	8793	2891	7.9	24.1
97	Repair services	389	9518	4113	4.1	9.5
34	Metal products	1270	31466	7147	4.0	17.8
27	Wood etc.	208	6257	1217	3.3	17.1
37	Transport equipment	2878	85415	18810	3.4	15.3
20&21	Food products	6165	207540	21721	2.9	28.4
22	Beverages, tobacco	857	28543	6813	3.0	12.6
35	Machinery	2144	83849	19455	2.6	11.0
36	Electrical machinery	2069	91590	21715	2.3	9.5
38	Other industry	251	12626	3284	1.9	7.6
30	Rubber, plastic	5575	169606	22328	3.3	24.9
29	Leather, fur	239	14467	1885	1.7	12.7
26	Textile products	409	21273	3414	1.9	11.9

Op: Output, VA: Value added

Source: Central Statistical Organization, Annual Survey of Industries, Summary Results for Factory Sector, 1985-86.

Fertilizer industry

In 1989/90, the fertilizer industry accounted for about 69% of all naphtha consumption in the country, along with about 41% of natural gas, 19% of furnace oil and 29% of LSHS/HHS. Relatively small quantities of HSD/LDO and electricity were also consumed. In terms of calorific content, natural gas has the largest share of energy consumption in the fertilizer industry.

In India, the production of nitrogenous fertilizers (particularly urea) is more than that of other types of fertilizers. Nitrogenous fertilizers are also relatively more energy intensive. However, the energy consumption intensity of urea manufacture has somewhat reduced during the past two decades or so. It may be related to the type of feedstock, technology employed, unit capacity and capacity utilization. These issues are discussed briefly below.

As one goes from heavier to lighter feedstock, the energy intensity reduces. This implies that (with other things held equal) the intensity reduces as the feedstock is changed from coal to fuel oil, from fuel oil to naphtha, and from naphtha to natural gas. However, a survey conducted by TERI shows that the intensity of using naphtha is marginally higher than that of using fuel oil. This may be due to a relatively lower capacity utilization of the naphtha-based plants surveyed. A continuous operation at high capacity leads to lower energy intensities, because plants functioning at lower loads also experience the same level of heat losses, purge losses and leaks, as those operating at full load. With an increase in plant load, it is clear that these "constant" losses have less impact on the overall energy consumption intensity.

Recent advances in process technologies and catalysts have also resulted in better intensity norms. For example, consumption of naphtha (feed and fuel) per tonne of ammonia guaranteed by various technology suppliers has reduced from 0.9 - 1.0 tonne during the seventies, to 0.8 - 0.85 tonne in the eighties. Similarly, the consumption of ammonia per tonne of urea has also reduced from 0.6 tonne to 0.58 tonne. Simultaneously, the stream sizes of urea making units have also grown, thus reaping the benefits of economies of scale.

Table III.3.5

Energy consumption in the fertilizer industry.

Energy form	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Naphtha ('000 tonnes)	2134	2365	2360	2488	2064	2395	2302[p]
Furnace oil ('000 tonnes)	574	553	500	787	979	1137	840[p]
LSHS/HHS ('000 tonnes)	913	911	1032	1203	873	951	1269[p]
Natural gas (million cubic metres)	1283	1603	2500	3335[p]	3490[p]	4132[p]	N.A.
HSD/LDO ('000 tonnes)	28	37	46	26	32	26	30
Coal (mt)	4.21	3.92	3.98	4.43	3.95	4.09	2.84
Electricity* (Gwh)	4464	3638	4161	N.A.	N.A.	N.A.	N.A.

* The total electrical energy consumed by the fertilizer industry of electrical energy purchased and generated internally. The consumption of coal, fuel oil etc. for internal generation of electricity is included in the consumption figures for the respective energy forms. Electricity consumption figures in the table are for purchased electrical energy only.

[p] provisional

Sources: [1] H. Harish and V.S. Kothari, "Energy Use in Fertilizer Industry", TERI Discussion Paper, 1987;
[2] Department of Petroleum, Indian Petroleum and Natural Gas Statistics, 1987-88;
[3] CMIE, Current Energy Scene in India, various issues; and
[4] CEA, Public Electricity Supply, General Review, various issues.

Table III.3.6

Production of fertilizers in 1990/91.

Fertilizer	Capacity ('000 t)	Production ('000 t)
Urea	14695	12835.9
Ammonium sulphate	1086.5	557.5
Calcium ammonium Nitrate	942.5	435.9
Ammonium chloride	132.0	78.8
Ammonium phosphate sulphate	220.7	528.2
Diammonium phosphate	2313.0	1904.9
Nitrophosphate	802.5	637.5
Single super phosphate	5107.5	3650.3
NP/NPK	2322.5	2312.2

Source: Fertilizer Association of India (FAI), Fertilizer Statistics 1990/91, New Delhi, December 1991.

Table III.3.7

Specific energy consumption for urea production* from different feedstock for ammonia.

Ammonia feedstock	Average capacity utilization (%)	Energy consumption (GCal/t urea)
Coal	26	29.01
Fuel oil	79.8	14.39
Naphtha	78	12.68
Gas	83	10.87

* Includes energy consumption in ammonia production.

Sources: [1] H. Harish and V.S. Kothari, "Energy Use in Fertilizer Industry", TERI Discussion Paper, 1987; Harish and Kothari (1987); and
[2] BICP, Energy Audit of Fertilizer Industry.

Table III.3.8

Nitrogen capacity according to sources of feedstock for ammonia (as of Oct. 1, 1991).

	Units	In production	Under implementation	Projects approved in principle/under consideration
Total	'000 tonnes N per annum	8211.0	1464.0	1002.0
Naphtha	%	30.0	-	-
Natural gas	%	41.6	88.0	100
Fuel oil	%	15.2	10.4	-
Coal gasification with partial oxidation	%	5.6	-	-
Coke/coke oven gas and others	%	1.3	1.6	-
Ammonia	%	6.3	-	-

Source: Fertilizer Association of India (FAI), Fertilizer Statistics 1990/91, New Delhi, December 1991.

Table III.3.9

Growth of stream size in ammonia and urea units in India.

Year	Ammonia (tonnes/day)	Urea (tonnes/day)
1969	500	800
1974	900	1500
1982	1350	1800
1983	2x1350	3x1500

Source: H. Harish and V.S. Kothari, 'Energy Use in Fertilizer Industry', TERI Discussion Paper, 1987.

Aluminium industry

At present, seven smelters are operated by five companies : (i) the Bharat Aluminium Company Ltd. (BALCO) at Korba in Madhya Pradesh; (ii) the Indian Aluminium Company (INDAL) at Belgaum in Karnataka, Hirakud in Orissa, and Alwaye in Kerala; (iii) the Hindustan Aluminium Company Ltd (HINDALCO) at Renukoot in Uttar Pradesh; (iv) the Madras Aluminium Company Ltd. (MALCO) at Mettur in Tamil Nadu; and (v) the National Aluminium Company Ltd. at Damanjodi in Orissa. The smelters at Korba, Belgaum, Renukoot, Damanjodi and Mettur are integrated plants, i.e., all process steps for converting bauxite to the finished product take place at the same location. For the INDAL smelters at Alwaye and Hirakud, alumina is the input material -- this alumina is produced at INDAL's alumina plant at Muri in Bihar.

India started producing aluminium in 1943. The real boost in terms of installed capacity of production occurred, in the sixties, a period when a boost was observed in the world production also. The installed capacity and production of the aluminium industry has grown steadily over the last ten years or so. The two major energy consuming steps are : bauxite ore conversion to alumina; and production of aluminium from alumina.

In the production of alumina, about 2.5 tonnes of bauxite is required and for the production of 1 tonne of alumina, about 2 tonnes of alumina is required. Fuel oil is used for firing calcining kilns. Besides calcination, some units also use fuel oil to generate the steam required for digestion and evaporation. Coal is used only for steam generation while electricity is used largely for bauxite grinding. Using about 110 litres of fuel oil per tonne of alumina, the calcination process at the INDAL's Muri and Belgaum plants is least energy intensive. This is due largely to better operation and improved heat recovery. The fuel oil consumption in calciners of other units is around 135 litres/tonne, which is comparable with the world norms.

Power is the major source of energy utilized in smelters for aluminium production. Its consumption in the Indian smelters is significantly higher than international norms. The energy consumption at various stages of aluminium production is as follows :

	Energy consumption %	Energy consumption MJ/t
i) Bauxite to Alumina	14	42,325
ii) Alumina to Aluminium	65	196,510
iii) Aluminium metal to ingot/slab	6	18,140
iv) Ingot slab to fabricated products	15	45,350
Total		302,325

Out of 18,140 MJ/t of energy required for conversion of aluminium to ingot/slab, around 17,441 MT/t is consumed in melting/holding furnace. Similarly, out of 45,350 MJ/t of energy requirement for conversion of ingot/slab to fabricated products, around 23,255 MJ/t are consumed in homogenising, preheating, annealing etc. If the energy consumption in this area can be optimised, overall production cost of fabricated products could be brought down.

Electricity is the major source of energy utilized in smelters for aluminium production. Petroleum coke, coal tar pitch and coke, which may also be used as an energy fuel, are used for anode making. Besides, fossil fuels are also required for steam generation. The electricity intensity at BALCO and MALCO is relatively high, mainly because of unavailability of adequate and steady power supplies -- which lead to frequent shut-downs and low capacity utilization.

All data in Tables III.3.10 through III.3.13 are obtained from : N.Thangaraju and V.S. Kothari, "Energy Use in Aluminium Industry", TERI Discussion Paper DP/02/86, New Delhi, 1986 and Ministry of Science and Technology, Department of Scientific and Industrial Research __ Technology Evaluation and Norms Study for Aluminium Industries, 1988.

Table III.3.10

Installed capacity, production and capacity utilization of the aluminium industry.

Year	Installed capacity ('000 tonnes)	Production ('000 tonnes)	Capacity utilization (%)
1970/71	156	167	107.1
1975/76	246	187	76.0
1979/80	321	192	59.8
1980/81	331	199	60.1
1981/82	331	207	62.4
1982/83	331	208	62.9
1983/84	332	220	66.7
1984/85	332	275	83.3
1985/86	362	260	71.7
1986/87	378	258	68.4

Source: BICP, Energy Audit of Aluminium Industry.

Table III.3.11

Energy requirements in alumina production (per tonne of alumina)a

	BALCO	HINDALCO	INDAL Belgaum	INDAL Muri	MALCO	NALCO*
Electricity (kWh/t of alumina)	437	384	241**	317	318	380
Coal (t/t of alumina)	NI	1.046	NA	1.34	NA	0.75
Fuel oil (t/t of alumina)	0.1256	0.088	0.248	0.103	0.134	0.085

NA: Not available; NI: Not indicated

* Actual norms are not available as the plant was still under commissioning state in 1986-97

** Low production

Table III.3.12

Power consumption of Indian aluminium industries per tonne of aluminium production.

Plants	Design norms (DC-kWh)	Actual performance (DC-kWh)
HINDALCO	18000	17030
BALCO	16020	16020
MALCO	16800	17030
INDAL	17800	17060
NALCO	13742	-

Source: GOI, Ministry of Science and Technology, Department of Scientific & Industrial Research, 1988.

Table III.3.13

Energy use in aluminium plants - an international comparison (per tonne of alumina).

	India	Australia	Guinea	Jamaica	Surinam
Thermal (GCal)					
Steam	3492.1	3601.4	3235.6	3965.6	848.9
Calcination	1242.5	1221.2	1221.2	1221.2	1221.2
Electrical (kWh)					
Electricity	362	240	240	240	240

Source: BICP, Energy Audit of Aluminium Industry.

Textile industry

The textile industry comprises : (i) cotton textiles; (ii) wool, silk and synthetic fibre textiles; and (iii) jute textiles. Cotton textile manufacture, which is the predominant sub-sector in the textile industry, consists of : (i) the organized sector; and (ii) the decentralized sector, which has both power-loom and hand-loom mills. The organized cotton textile sub-sector, which has about 700 mills, is facing financial problems, not only because it is labour intensive, but also because it has old and antiquated machinery and a poor maintenance record.

The textile industry consumes around 9% of the total commercial energy consumed in the country. About 80-85% of its energy needs are thermal, and the rest electrical. Coal and furnace oil meet the process heat requirements. All textile mills, except for those around Bombay, use coal in boilers. An estimated 80-90% of the electricity used is for motive power for driving pumps, motors, drives etc. The energy bill of most textile mills accounts for 10- 15% of the total input costs.

There is a substantial scope for energy conservation in the textile industry. Low efficiency boilers, with efficiency levels of 50-60% are in operation in a large number of mills. These boilers may easily be retrofitted with suitable heat recovery equipment. Besides, cogeneration may also be possible, because several mills use 60% of the required steam below 60 psig, while their boilers generate steam at 150 psig or more.

Table III.3.14
Textile industry -- index number of capacity, production and capacity utilization.

Year	Capacity	Production	Capacity utilization (%)
1970	100.0	100.0	75
1975	105.5	108.1	77
1976	110.7	112.1	76
1977	115.0	111.0	72
1978	113.5	117.8	78
1980	120.0	123.9	77
1981	119.3	127.4	80
1982	128.9	107.0	62
1983	129.2	116.5	68
1984	129.7	106.7	62
1985	133.7	117.6	66
1986	133.6	121.3	68

Source: Centre for Monitoring Indian Economy, Production and Capacity Utilization in 600 Industries, various issues.

Table III.3.15
Existing structure of the textile industry.

	Handloom (%)	Powerloom (%)	Organized sector (%)	Total cloth output (million metres)
1979/80	29	30	41	10454
1986/87	26	48	26	12800

Source: The Hindu, June 4, 1987.

Table III.3.16

Energy consumption in the textile industry.

Year	Electricity (GWh)			Coal (mt)			Fuel oils* ('000 t)
	Textile	Jute	Total	Jute	Cotton	Total	
1970/71	3950.5	659.8	4610.3	-	-	-	-
1973/74	4055.6	651.5	4701.1	0.14	1.78	1.92	-
1976/77	5123.9	880.4	6004.3	0.18	2.41	2.59	570
1979/80	5743.2	700.2	6443.4	0.14	1.99	2.13	430
1982/83	5909.4	761.3	6670.7	0.17	2.94	3.11	334
1984/85	7448.0	794.1	8242.1	0.12	2.57	2.69	430
1985/86	8348.7	820.2	9168.9	0.12	2 36	2.48	459
1986/87	-	-	-	0.17	2.44	2.61	470
1987/88	-	-	-	0.14	2.54	2.68	442

* Includes Furnace oil, LSHS, and HHS.

Sources: [1] CEA, Public Electricity Supply (All India Statistics): General Review, New Delhi, various issues;

[2] Department of Petroleum, Indian Petroleum & Petrochemical Statistics, New Delhi, various issues;

[3] Coal controllers Organization, All India Annual Coal Statistics, various issues, GOI, Calcutta; and

[4] CMIE, Current Energy Scene in India, July 1989.

Table III.3.17

Energy use intensity of the textile industry.

	Electricity (kWh)	Coal (kg)
Cotton (per metre)	0 9	0.75
Polyester (per metre)	-	1.25
Jute (per tonne)	545	23.2

Source: Inter-Ministerial Working Group, "Utilization and Conservation of Energy - Sectoral Reports", New Delhi, 1983.

Cement industry

During the Sixth FYP period, the Indian cement industry recorded significant growth. Production grew at 10% per annum, and installed capacity at 13%. By the end of the Seventh FYP period, the installed capacity is expected to rise to about 62 mt.

At present, the Indian cement industry produces thirteen varieties of cement, of which three comprise more than 95% of the total production. These are ordinary portland cement; portland pozzolona cement; and portland slag cement.

The technology for cement manufacture has changed substantially in India, during the past three to four decades. While plants based on the wet process were established in the fifties and early sixties, those with dry process have been set-up thereafter. Dry process cement plants, which are comparatively less energy intensive, now account for over 60% of the installed capacity. The precalcinator technology has also now been introduced in India.

Electric power and coal are the major energy forms used in the cement industry, although some plants use furnace oil and lignite also. The cement industry accounts for over 10% of the industrial sector's coal consumption, and over 6% of the sector's electricity consumption. Although the overall energy intensity of the cement industry has declined during the past decade or more (due largely to an increasing share of production from dry process based cement plants), the energy consumption norms in India are significantly higher than what has been achieved internationally.

A further reduction in energy intensity is likely to be possible from one, basing all future plants on the dry process; and two, better house-keeping at the plant level.

All data in Tables III.3.18 through III.3.20 are obtained from TERI data files.

Table III.3.18

Energy consumption in the cement industry.

	1973/74	1976/77	1979/80	1982/83	1985/86
Electricity (GWh)	1283.8	2340.1	2035.7	2516.9	3467.3
Coal ('000 tonnes)	3650	4970	3870	6100	7900
Fuel oils ('000 tonnes)	NA	42	154	41	54

Table III.3.19

Energy consumption norms per tonne of OPC cement.

Process	Thermal		Electrical (kWh)	Total (GCal)
	Gcal	Coal (kg)		
Wet	1.59	330	118	1.69
Dry	0.98	214	135	1.098
Semi-dry	1.11	248	135	1.226

Note: 1 kWh = 860 kCal

Table III.3.20

Energy consumption in 1983/84 comparison with international consumption.

Process	Energy type	Indian scenario	World scenario
Wet	Electricity (kWh/tonne)	114	87
	Thermal (GCal/tonne)	1.657	1.243
Dry	Electricity (kWh/tonne)	155	111
	Thermal (GCal/tonne)	0.977	0.769

Iron and steel industry

In India, six integrated steel plants are under operation at present. These are, Tata Iron and Steel Co. (TISCO), Durgapur Steel Plant (DSP), Rourkela Steel Plant (RSP), Bhilai Steel Plant (BSP), Bokaro Steel Ltd. (BSL), and Indian Iron and Steel Co. (IISCO). The Vizag Steel Plant is expected to come up shortly.

The steel making capacity in India has increased to about 22.5 million tonnes of ingots per year. Of this, integrated steel plants account for 17.3 mt, taking the 2.5 mt capacity of VSP into account. In addition, there are 211 Arc Furnaces known as Mini Steel Plants holding licences with a total capacity of 7.9 mt of ingots per year. In the year 1988-89, the contribution of the integrated steel plants towards the total production of steel of 13.94 mt was 10.6 mt.

The primary sources of energy going into the steel plants are coking coal, non-coking coal, liquid HC and electricity.

The two most energy intensive steps in this industry are the iron making at blast furnace and making liquid steel from the hot metal in blast furnaces. Iron making at blast furnaces consumes nearly 70% of the total energy input to the total system. Net energy consumption in Indian plants varies from 4.168 GCal/tonne of hot metal in TISCO to 7.029 GCal in DSP, which are higher by 29% and 118%, respectively, than the consumption of 3.221 GCal in the U.K.

The efforts to reduce specific energy consumption at steel melting furnaces with higher productivity, led to the introduction of basic oxygen furnace (bof), replacing the old open hearth furnace (ohf) of steel making from hot metal. In fact, ohf has virtually ceased to be in use in Japan and the CEC countries. The bof consumes much less energy. In India, the ohf is declining rapidly and LD converter and Electric Arc furnaces are becoming more prominent.

Table III.3.21

Electricity - generated, purchased and consumed in main steel plants (GWh)

Plants	1987-88	1988-89
BSP		
Generated	348.7	452.7
Purchased	1137.0	1162.4
Consumed	1457.3	1606.5
BSL		
Generated	629.5	791.8
Purchased	939.0	848.9
Consumed	1343.6	1388.1
DSP		
Generated	248.7*	491.9
Purchased	242.1	123.6
Consumed	379.0	388.3
RSP		
Generated	561.7	959.9
Purchased	514.7	236.7
Consumed	1076.3	1196.6
IISCO		
Generated	111.3	139.6
Purchased	150.3	120.6
Consumed		
TISCO		
Generated	746.2	745.9
Purchased	582.8	613.3
Consumed	1328.9	1359.1

* Supplied to alloy steel plants.

Source: Statistics for Iron and Steel Industry in India, 1990, SAIL.

Table III.3.22
Operating statistics of steel plants

Plant	Kg of coke/tonne of hot metal	Kg of not metal/tonne of ingot	BF coke/Dry coal ratio (%)	Dry coal per tonne of hot metal	Dry coal per tonne of crude steel
BSP	682	884	68.22	999.7	883.7
BSL	666	951	65.5	1016.8	966.9
DSP	856	866	62.56	1368,8	1184.9
RSP	736	1011	67.72	1086.8	1098.7
IISCO	1023	752	66.4	1540.6	1158.6
TISCO	716	639	64.8	1104.9	706.0

Source: Statistics for Iron and Steel Industry in India, 1990, SAIL.

Table III.3.23
Production of ingot steel. (mt)

Plant	1984-85	1985-86	1986-87	1987-88	1988-89
BSP	1.998	2.345	2.230	2.471	3.09
BSL	1.925	2.003	2.056	2.418	2.77
DSP	0.76	0.87	0.92	0.94	0.96
RSP	1.12	1.18	1.10	1.12	1.19
IISCO	0.44	0.56	0.53	0.54	0.47
TISCO	2.05	2.09	2.25	2.28	2.31

Source: Statistics for Iron and Steel Industry in India, 1990, SAIL.

Table III.3.24

Electricity consumption in steel plants (GWh)

Plant	1984-85	1985-86	1986-87	1987-88	1988-89
BSP	1123	1344	1414	1457	1606
BSL	1126	1465	1239	1344	1388
DSP	317	348	354	371	388
RSP	996	954	959	1076	1196
IISCO	247	263	262	261	259
TISCO	1179	1218	1207	1329	1359

Source: Statistics for Iron and Steel Industry in India, 1990, SAIL.

Conservation potential in Indian industries

The industrial sector in India consumes more than half of the total commercial energy available, 41% of electricity, 90% of coal and 19% of petroleum products. We see that the level of energy consumption has been extremely high in the Indian industries and continues to be so. In the study by the National Productivity Council (NPC) in 1983, it was found that on the whole about 25% of the energy consumed could be saved. The measures proposed to achieve this do not involve full- scale modernisation. Essentially, they are directed at better house- keeping, fuel-processing, optimisation combustion process, small changes in the production run and the replacement of obsolete equipment. According to the study done by the NPC, an investment of Rs.36000 million, would be required to implement the package of measures. As against this, the decrease in energy costs would come to over Rs.19000 million annually, and the saving in investment (which would have been necessary to supply the conserved energy additionally), is estimated to be around Rs. 58000 million. Thus, it could be concluded that, it is cheaper to save energy, than providing new infrastructure for energy supply.

A more recent study by V.Raghuraman on "Reducing energy intensity in selected Indian industrial subsectors, 1989", confirms that the savings potential remains considerable even at the end of eighties. The table that follows gives us an idea about the energy savings potential in some of the major industries in India.

Table III.3.25
Energy conservation potential in Indian industries

	% share of energy cost	Conservation potential (%)
Iron & Steel	15.8	8-10
Fertilizers & pesticides	18.3	10-15
Textile	10.9	20-25
Cement	34.9	10-15
Chlor-alkali	15.0	10-15
Pulp & paper	22.8	20-25
Aluminium	34.2	8-10
Ferrous foundry	10.5	15-20
Petrochemical	12.7	10-15
Ceramics	33.7	15-20
Glass	32.5	15-20
Refineries	1.0	8-10
Sugar	3.4	70-80
Ferro-alloys	36.5	8-10

Source: V Raghuraman, 1989.

Transport sector

Introduction

The share contribution of the transport sector (including communication and trade) to total GDP was about 18% in 1988/89. The gross value added by the transport sector grew by 5% per annum during the eight year period, 1980/81 to 1988/89. That transport services have grown, reflects not only a growth in economic activity, but also an increase in leisure related travel.

The transport sector is a major energy consuming -- and oil consuming -- sector. It is therefore important to analyze the implications on energy consumption, of any transport planning/policy-formulation exercise.

Since the mid sixties, the transport sector has accounted for 12-16% of total public sector investments; while it accounted for as much as 22-23% of public investments during the First, Second and Third FYP periods. Of the total public sector investments on transport, over 75% has always been reserved for the rail and road sub-sectors. Consequently, these two modes are the major forms of transport in the country.

The railways' share of both freight and passenger traffic has decreased since the early sixties. This may be due to the relative decline in the railways' share of public sector expenditures, particularly from the Third FYP period to the Sixth FYP Period -- when the share of traffic handled by road increased rather rapidly. The role of road transport grew also because, in addition to public investment, there is considerable private investment as well -- as evident from the private ownership of cars/taxis, two/three-wheelers, trucks and other vehicles. However, it appears that the Government is making an effort to reverse this trend during the Seventh FYP period, by allocating for the railways, nearly 55% of the public sector outlay for the entire transport sector.

Table III.4.1
Plan allocations for the transport sector. **(%)**

Sub-Sector	1st Plan	2nd Plan	3rd Plan	Annual Plans	4th Plan	5th Plan	6th Plan	7th Plan
Railways	50.0	65.7	66.9	49.3	37.0	40.6	42.2	54.6
Roads & Road Transport	33.9	22.0	23.5	5.3	39.3	33.5	38.4	31.8
Shipping *	10.8	7.8	6.9	8.4	16.3	19.1	11.7	9.2
Inland Water Transport	-	-	0.2	0.6	0.4	0.6	0.6	1.0
Civil Air Transport	5.3	4.5	2.5	6.4	7.0	6.2	7.1	3.4

* Includes all Ports and Lighthouses.
Sources:[1] Planning Commission (GOI), Report of the National Transport Policy Committee, New Delhi, May 1980;
[2] Planning Commission (GOI), Seventh Five Year Plan, 1985-90 Vol.II, New Delhi, October 1985.

Table III.4.2
Value added in transport sector.
(Rs. million, 1980/81 Prices)

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
Total	**50290**	**52960**	**55240**	**58890**	**64120**	**70440**	**75140**	**81970**
Railways	11240	12200	12470	12430	12670	14040	15140	15760
Road	24540	26410	28670	32260	35010	38610	41840	46100
Water	8230	7420	6710	6060	7670	8430	8150	9040
Air	2550	2820	3020	3400	3570	3610	3890	4390
Service incidental to transport	2510	2790	3030	3340	3670	4120	4440	5000
Storage	1220	1320	1340	1400	1530	1630	1680	1680

Source: Central Statistical Organization, National Accounts Statistics, GOI, New Delhi, 1990.

Table III.4.3

Trends in relative rail and road traffic.

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86	1988/89
Freight Traffic							
Total (billion t-km)	194.408	199.054	251.531	285.845	365.891	422.68	505.00
Rail (%)	65.5	61.5	62.3	54.6	48.6	48.7	46.0
Road (%)	34.5	38.5	37.7	45.4	51.4	51.3	54.0
Passenger Traffic							
Total (billion p-km)	359.05	427.6	549.325	710.4	955.9	1079.202	1169.00
Rail (%)	32.9	31.6	29.7	27.9	23.7	22.2	23.0
Road (%)	67.1	68.4	70.3	72.1	76.3	77.8	77.0

Sources: [1] Railway Board (GOI), Indian Railways, Annual Statistical Statements, various issues;
[2] Engineering Consultants pvt. Ltd., Report on "Estimation of Total Road Transport, Freight and Passenger Movement in India for the year 2000 A.D, Prepared for the Department of Surface Transport (Road Wing), GOI, January 1987; and
[3] CMIE, Basic Statistics 1990.

Railways

The Indian Railway system is over a hundred year's old, with a route network of nearly 62,000 km and a running track of over 134,000 km. It developed as a multi-gauge system with tracks in the broad gauge (1.76 metres wide), the metre gauge (1.0 metre wide) and the narrow gauge (0.762 metre and 0.610 metre wide). As a result, the railways have suffered from problems of change/break of gauge for long haul movements.

Since the early sixties, a significant share of investments have been for upgrading metre and narrow gauge tracks to broad gauge tracks, as well as for laying additional broad gauge tracks on existing routes. The expansion of broad gauge tracks has been promoted because it enables a relatively higher tonnage of traffic throughput.

The Government initiated the track electrification programme in the fifties. However, recognizing that electrification is capital intensive and economical only if traffic density exceeds a certain threshold level, dieselization of railways was considered a viable alternative in the interim period. Consequently, diesel traction increased much faster than electric traction, as traffic carried by the railways did not expand as anticipated (thus making electrification viable only on rather small portions of the track network). Furthermore, a concerted effort to phase out steam engines also led to an increase in diesel traction.

Total revenue and non-revenue earning freight traffic increased at a rate of 3.2% per annum from 1970/71 to 1989/90. Freight traffic in fact stagnated during the mid and

late seventies, and picked up only after 1979/80, when it increased at a rate of 5.2% per annum until 1988/89. Although this slow growth in freight throughput of the railways during 1976/77 to 1979/80 may have been due to a stagnation in economic activity (such as coal production, iron ore exports etc.), it also reflected the presence of bottlenecks in the railway system.

In fact, for revenue earning freight traffic (which accounts for over 90% of total freight traffic), there has been a general trend of an increase in the average lead distance. This perhaps indicates that a gradually increasing share of short haul freight traffic has been handled by other modes of transport. The same is true for both suburban and non-suburban passenger traffic as well. Average lead distance in suburban passenger traffic increased with the extension of the railway network to more distant suburbs of Bombay, Calcutta and Madras; while the increase for non-suburban traffic occurred largely because public sector road transport services began to cater to short distance inter-city/inter-town passenger traffic.

Energy consumption data disaggregated for freight and passenger traffic are not available, except for electricity consumption data for suburban passenger traffic. Energy consumption per gross tonne-km equivalents of freight and passenger traffic may be estimated at an aggregate level. Available data indicate that there has been a steady decline in the overall energy consumption intensity of the rail transport system since 1970/71, but only due to a major switch in locomotive power, from energy intensive coal to diesel and electricity (intensity of steam locomotion in fact increased as steam engines began to be used increasingly for short haul movements, with several halts). The number of coal using steam locomotives reduced substantially, while the stock of diesel and electric locomotives increased. It is therefore clear that once all steam locomotives are out of service, further overall improvements may be possible only through design improvements and/or better management.

Table III.4.4

Electrified and non-electrified rail track.

(Kilometres)

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86	1988/89	1989/90
Total route-km	**59790**	**60234**	**60666**	**60890**	**61385**	**61836**	**61985**	**62211**
Broad gauge	29449	30210	30873	31239	32624	33669	34108	34544
Metre gauge	25865	25548	25512	25370	24515	23921	23631	23599
Narrow gauge	4476	4476	4281	4281	4246	4246	4247	4068
Total track-km	71669	74105	74840	75450	76197	106502	132881	134483
Broad gauge	40825	42756	43743	44410	46309	69150	97313	98786
Metre gauge	26362	26873	26816	26759	25642	32589	31472	31654
Narrow gauge	4482	4476	4281	4281	4246	4763	4096	4043
Electrified route	**3420**	**4190**	**4719**	**4820**	**5815**	**6516**	**8880**	**9100****
Broad gauge	NA	4024	4553	4654	6649	6350	8714	8934
Metre gauge	NA	166	166	166	166	166	166	166
Electrified track	**NA**	**8402**	**9373**	**9562**	**11059**	**16086**	**35214**	**36929**
Broad gauge	NA	8181	9152	9341	10838	15758	34813	36501
Metre gauge	NA	221	221	221	221	328	401	428

** This does not include 152 km, which, though energised, has not been opened to traffic

Source: Railway Board (GOI), Indian Railways, Annual Statistical Statements, various issues.

Table III.4.5

Number of operating locomotives (As on March 31 of Each Year).

	1971	1974	1977	1980	1983	1985	1988	1989	1990
Total	**11158**	**11126**	**11095**	**11073**	**10087**	**10128**	**9158**	**8813**	**8590**
Steam	9387	8847	8345	7856	6292	5970	4427	3826	3336
Diesel	1169	1610	1903	2243	2638	2905	3298	3454	3610
Electric	602	669	847	974	1157	1253	1433	1533	1644

Source: [1] Railway Board (GOI), Indian Railways, Annual Statistical Statements, various issues;

[2] Indian Railways, Yearbook 1989-90.

Table III.4.6
Rail freight traffic (net million t-km).

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86	1988/89	1989/90
Revenue earning traffic	**110698**	**109391**	**144031**	**144559**	**167780**	**196600**	**222374**	**229602**
Coal	27837	26587	38756	35340	47893	64401	82694	85112
Raw Material for Steel plants	2708	2675	4639	4482	5379	5354	6914	7825
Pig iron and from Steel plants	6201	6179	9882	8063	10093	10406	11605	11794
Iron ore for Export	5492	4275	6408	6188	5761	7273	7843	8516
Cement	6990	6368	9170	7442	9159	11729	16895	17742
Food grains	14505	16322	18757	23474	30417	32714	33436	33676
Fertilizers	3808	4001	7225	9240	8252	14900	16267	17375
Mineral Oils	5264	6373	7552	10398	11212	10959	14135	15674
Other commodities	37891	36612	41641	39933	39614	38864	32585	33888
Non-revenue earning traffic	**16662**	**12963**	**12725**	**11437**	**9986**	**9303**	**7758**	**7316**
Total traffic	**127358**	**122354**	**156756**	**155995**	**177766**	**205903**	**230131**	**236917**

Source: Railway Board (GOI), Indian Railways, Annual Statistical Statements, Various issues

Table III.4.7
Average lead distance of freight moved by rail (km).

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86	1988/89	198
Revenue earning traffic	**659**	**675**	**677**	**749**	**733**	**760**	**736**	**741**
Coal	581	562	575	570	582	634	646	654
Raw materials for steel plants	169	168	200	216	229	233	264	285
Pig iron & finished steel from steel plants	993	1009	1000	1117	1207	1176	1140	1162
Iron ore for export	560	506	644	667	582	580	575	577
Cement	633	635	668	741	718	653	652	646
Food grains	961	1114	940	1279	1231	1357	1344	1339
Fertilizers	811	753	929	1122	969	1094	1010	1024
Mineral oils	559	638	609	729	647	588	626	645
Other goods	787	826	861	929	957	1017	943	966
Non-revenue traffic	**583**	**568**	**480**	**462**	**367**	**334**	**283**	**301**
Railway coal	937	801	743	721	649	700	711	731
Railway stores & materials*	109	50	246	229	239	228	44	47
Diesel for railways	-	538	472	561	537	443	476	519

* Railways stores and materials carried in other than departmental wagons and ballast trains.

Source: Railway Board (GOI), Indian Railways, Annual Statistical Statements, Various issues.

Table III.4.8
Rail passenger traffic.

	1970/71	1973/74	1976/77	1979/80	1982/83	1985/86	1988/89	1989/90
Passengers carried (million)	**2431**	**2653**	**3300**	**3505**	**3656**	**3433**	**3500**	**3653**
Suburban	1227	1437	1802	1903	2029	1884	2005	2110
Non-suburban	1204	1216	1498	1602	1627	1549	1495	1543
Passenger km (billion)	**118**	**135**	**163**	**198**	**227**	**240**	**264**	**281**
Suburban	23	28	37	38	46	45	52	55
Non-suburban	95	107	126	160	181	195	212	226
Average no. of km a passenger was carried	**48.6**	**51.1**	**49.6**	**56.7**	**62.1**	**70.1**	**75.3**	**76.9**
Suburban	18.8	19.5	20.6	20.4	22.6	24.1	25.9	26.0
Non-suburban	78.9	88.5	84.6	99.8	111.4	126.0	141.6	146.4

Source: Railway Board (GOI), Indian Railways, Annual Statistical Statements, Various issues

Table III.4.9

Rail freight and non-suburban passenger traffic.

	Broad gauge	Metre gauge	Narrow gauge	All
1970/71				
Total traffic (bgt-km)	**305.756**	**73.608**	**2.062**	**381.43**
% Passenger	27.9	43.2	58.5	31.0
% Freight	72.1	56.8	41.5	69.0
% Steam	41.1	73.5	88.6	47.6
% Diesel	38.8	25.1	11.4	36.0
% Electric	20.1	1.4	-	16.4
1982/83				
Total traffic (bgt-km)	**435.294**	**70.419**	**1.51**	**507.22**
% Passenger	28.7	47.1	72.1	31.4
% Freight	71.3	52.9	27.9	68.6
% Steam	11.5	39.7	73.7	15.6
% Diesel	57.3	58.6	26.3	57.4
% Electric	31.2	1.7	-	27.0
1987/88				
Total traffic (bgt-km)	**513.583**	**61.89**	**1.017**	**576.491**
% Passenger	26	45	74	28.1
% Freight	74	55	26	71.9
% Steam	5.1	25.3	29.6	7.3
% Diesel	58.5	72.9	70.4	60.1
% Electric	36.4	1.8	-	32.6
1988/89				
Total traffic (bgt-km)	**579.981**	**71.315**	**1.369**	**652.666**
% Passenger	29	48	74	31.02
% Freight	71	52	26	68.98
% Steam	5.8	27.5	31.2	8.2
% Diesel	55 8	70.2	68.8	57.5
% Electric	38.4	2 3		34.3
1989/90				
Total traffic (bgt-km)	**600.732**	**73.304**	**1.358**	**675.397**
% Passenger	29	48	74	31.3
% Freight	71	52	26	68.7
% Steam	4.6	25.5	26.4	7.0
% Diesel	55.4	72.8	73.6	56.6
% Electric	41.0	1.7		36.4

Source: Railway Board (GOI), Indian Railways, Annual Statistical Statements, various issues.

Table III.4.10

Energy consumption in railways.

<table>
<tr><th></th><th>1970/71</th><th>1973/74</th><th>1976/77</th><th>1979/80</th><th>1982/83</th><th>1985/86</th><th>1988/89</th><th>1989/90</th></tr>
<tr><td>Freight &, non-suburban passenger traffic.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Coal (mt)</td><td>14.3</td><td>12.7</td><td>12.2</td><td>11.4</td><td>9.4</td><td>8.6</td><td>6.1</td><td>5.4</td></tr>
<tr><td>Furnace oil ('000t)</td><td>NA</td><td>63</td><td>76</td><td>68</td><td>51</td><td>44</td><td>32</td><td>22</td></tr>
<tr><td>Diesel oils ('000t)</td><td>569</td><td>681</td><td>847</td><td>981</td><td>1227</td><td>1224</td><td>1653</td><td>1491</td></tr>
<tr><td>Electricity (GWh)</td><td>NA</td><td>977</td><td>1447</td><td>1574</td><td>1876</td><td rowspan="2">3182</td><td rowspan="2">4951</td><td rowspan="2">5338</td></tr>
<tr><td>Electricity for (GWh) suburban passenger traffic</td><td>372</td><td>407</td><td>492</td><td>578</td><td>608</td></tr>
</table>

Sources: [1] Railway Board (GOI), Indian Railways, Annual Statistical Statements, various issues;

[2] Coal controllers Organization, Coal Statistics, various issues;

[3] Department of Petroleum and Natural Gas Statistics, various issues

[4] CEA, Public Electricity Supply, All India, General Review, various issues; and

[5] IR, Yearbook 1989-90.

Table III.4.11
Energy intensity in railways.
(toe/million gross t-km)

<table>
<tr><th></th><th>1970/71</th><th>1976/77</th><th>1982/83</th><th>1986/87</th><th>1987/88</th></tr>
<tr><td>All non-suburban passenger & freight traffic</td><td>19.8</td><td>15.2</td><td>11.3</td><td>8.6*</td><td>8.4*</td></tr>
<tr><td>Steam</td><td>38.6</td><td>42.4</td><td>54.7</td><td>72.6</td><td>75.7</td></tr>
<tr><td>Diesel</td><td>4.1</td><td>3.9</td><td>4.2</td><td>3.9</td><td>3.9</td></tr>
<tr><td>Electric</td><td>-</td><td>1.2</td><td>1.1</td><td rowspan="2">1.1</td><td rowspan="2">1.2</td></tr>
<tr><td>Suburban passenger traffic</td><td>0.87</td><td>0.71</td><td>0.71</td></tr>
</table>

* Includes electricity consumed for suburban passenger traffic movement.
Source: Railway Board (GOI), Indian Railways, Annual Statistical Statements, Various issues.

Road transport

In contrast to the railway track network, the road network has increased considerably during the past two decades. Roads have been extended to rural and remote areas also, where road transport vehicles have become the only means of transport. Unlike the railways, this sector is not organized (perhaps because of the dual ownership pattern), and the data base is therefore rather weak. Firm and up-to-date information on ownership pattern for trucks (which are predominantly in the private sector) is lacking. The information base on passenger-km and freight tonne-km travelled is not very reliable. And the consumption of petroleum products is known only at an aggregate level-- no break-up of petrol and diesel use by types of vehicles are available. Furthermore, at least for diesel, a certain fraction (unknown) may actually be consumed for agriculture.

For these reasons, it becomes difficult to estimate the relative shares of private and public modes of road passenger traffic. According to the Report of the Working Group on Energy Policy (GOI, New Delhi, 1979) the share of passenger traffic through private modes increased gradually up to the year 1978/79, when it was about 23%. Yet, with apparently "reasonable" assumptions regarding annual utilization rates and occupancy levels, the Department of Surface Transport GOI(1987), estimates that the share of private modes of transport has varied from 17% to 20% from 1970/71 to 1985/86. Estimates of the annual utilization patterns and occupancy ratios used for these computations are based on isolated sample surveys conducted in various cities/towns, and no time series

data are available. Likewise for trucks,no reliable time series data are available on the origin/destination of freight carried, types of commodities etc.

Data on the energy consumption intensity by various types of motorized vehicles are available; but these intensity figures relate only to test conditions. It is known that petrol/diesel consumption intensity of vehicles is minimum only at a certain speed, and that too, on a smooth, flat, wide road. To the extent vehicles are driven at speeds below or above the optimal speed, and the roads are undulating and rough, the petrol/diesel consumption intensity may be higher.

Urban energy demand projections in the passenger transport during 2001 is presented in table III.4.19 as per present trends and as per NCU recommendations.

Table III.4.12

Road length. ('000 km)

	Surfaced	Unsurfaced	Total	National highways
1960/61	234	471	705	23
1971/72	436	576	1012	28
1972/73	474	654	1128	29
1973/74	499	672	1171	29
1974/75	523	692	1215	29
1975/76	551	698	1249	29
1976/77	572	736	1308	29
1977/78	596	776	1372	29
1978/79	622	823	1445	29
1979/80	647	846	1493	29
1980/81	684	807	1491	32
1984/85	788	899	1687	32
1985/86	825	901	1726	32
1986/87	858	922	1780	32

contd...

Table III.4.12 (contd.)
Road length. ('000 km)

	Surfaced	Unsurfaced	Total	National highways
1987/88	888	955	1843	32
1988/89	920	985	1905	33
1989/90*	960	1010	1970	34

* provisional.

Sources: [1] Centre for Monitoring Indian Economy (CMIE), Basic Statistics relating to the Indian Economy, vol.I All India, various issues;
[2] Economic Survey 1990.

Table III.4.13
Population of registered motor vehicles in India.
('000)

	Passenger cars, jeeps & taxis	Buses	Trucks	Two wheelers	Others	Total
1960/61	310	57	168	88	42	665
1970/71	682	94	343	576	170	1865
1980/81	1117	154	527	2528	847	5173
1981/82	1207	164	587	2963	922	5844
1982/83	1351	178	648	3512	1025	6719
1983/84	1424	196	719	4234	1168	7759
1984/85	1540	213	783	4960	1287	8796
1985/86	1627	230	848	5798	1379	9882
1986/87	1731	246	902	6749	1417	11045
1987/88	2055	260	1015	8493	1663	13486
1988/89	2284	293	1140	10685	2086	16488

Source: Centre for Monitoring Indian Economy (CMIE), Basic Statistics relating to the Indian Economy, vol. I All India, various issues.

Table III.4.14

Growth of vehicles and its composition.

	Year	Total vehicles ('000)	Annual compound growth (%)	Vehicle composition in percentage				
				Two wheeler	Three wheeler	Car, taxi,jeep	Bus	Others
Calcutta	1986-87	351	14.63	39	1	48	1	10
Bombay	1986-87	524	13.74	36	8	49	1	7
Delhi	1986-87	1112	20.47	69	3	20	1	6
Madras	1986-87	373	93.11	63	2	26	1	8
Bangalore	1986-87	359	18.30	72	3	19	2	5
Ahmedabad	1986-87	232	19.77	71	12	12	2	3
Hyderabad	1986-87	303	45.86	77	5	11	1	6
Pune	1986-87	213	21.02	72	7	11	1	9
Kanpur	1986-87	127	26.75	80	2	8	..	10
Nagpur	1986-87	98	11.71	79	3	10	1	8
Jaipur	1986-87	163	18.10	66	2	14	4	14
Lucknow	1986-87	124	31.75	77	1	10	1	11
Madurai	1988-89	53	23.26	70	1	14	2	12
Patna	1987-88	73	31.10	71	4	24	1	10
Coimbatore	1987	150	9.11	81	2	12	1	4
Vadodara	1987-88	188	12.33	70	6	11	5	8
Bhopal	1988	101	14.10	74	a	13	1	12
Cochin	1988	60	11.37	57	82	12	3	n.a.

a. included in taxis

n.a. denotes not available

Source: Data on first 12 cities are compiled from [ACMA, 1990]. Whereas, for the remaining cities data is compiled from [CIRT, 1987-89] reports.

Table III.4.15
Number of bicycles manufactured in India ('000).

Year	Numbers
1961/62	500
1964/65	800
1970/71	1700
1974/75	2000
1978/79	3500
1979/80	3830
1980/81	5100
1981/82	4830
1982/83	5097
1983/84	5807
1984/85	5830
1985/86	5700
1986/87	6120
1987/88	6676

Source: CMIE, Production and Capacity Utilization in 630 Industries, various issues.

Table III.4.16
Mobility and congestion indicators for selected cities.

Cities	Road length per 1000 population (km)	PCU's per [a] km of road
Calcutta	0.09	256
Bombay	0.17	230
Delhi	0.28	331
Madras	0.39	56
Bangalore	0.41	150
		contd...

Table III.4.16 (contd.)
Mobility and congestion indicators for selected cities.

Cities	Road length per 1000 population (km)	PCU's per [a] km of road
Ahmedabad	0.35	127
Hyderabad	0.51	203
Pune	0.31	195
Kanpur	0.58	51
Patna	0.45	100
Coimbatore	0.92	77
Cochin	0.24	144

[a] PCU = Passenger car Units

Note: Bus = 3 PCU;
2-Wheeler = 0.5 PCU;
3-wheeler = 0.75 PCU

Source: Transport Study of Selected Cities, Central Institute of Road Transport, Pune.

Table III.4.17
Modal split of passenger trips.

Cities	Year	Walk	Bicycle	Two wheeler	Auto rickshaw	Car, taxi	Bus		train	Cycle rickshaw
							Public	Private		
Calcutta	1984	NA	NA	NA	NA	NA	72.00	A	20.00	8.00
Bombay	1986	NA	NA	4.00	11.00	18.00	34.00	A	33.00	-
Delhi	1987	50.50	1.70	8.90	8.00	6.50	30.60	A	0.10	0.90
Madras	1984	NA	15.00	5.00	1.00	2.50	63.00	A	13.00	1.00
Bangalore	1988	27.50	3.00	13.00	1.00	4.40	50.80	A	0.30	-
Ahmedabad	1988	42.37	15.47	13.39	8.66	0.82	18.69	0.54	0.07	-
Hyderabad	1989	41.73	9.35	10.76	7.89	1.39	27.00	1.33	0.55	-
Pune	1986	38.94	17.13	17.30	6.30	1.05	13.86	4.68	0.74	-
Kanpur	1987	40.15	31.70	11.20	1.35	1.00	1.50	A	1.30	11.80
Madurai	1989	34.40	9.80	3.40	3.60	0.30	29.40	0.70	0.20	18.20

contd...

Table III.4.17 (contd.)

Modal split of passenger trips.

Cities	Year	Walk	Bicycle	Two wheeler	Auto rickshaw	Car, taxi	Bus		train	Cycle ricksl
							Public	Private		
Coimbatore	1987	44.54	13.25	6.15	1.25	0.91	33.41	0.45	0.04	-
Vadodara	1989	38.66	11.95	13.20	13.37	2.50	19.11	1.17	0.04	-
Bhopal	1989	45.37	11.38	13.78	1.68	0.88	20.35	6.49	0.07	-
Cochin	1989	38.07	6.18	10.44	1.49	1.30	-	40.16	-	2.36

A Included in Public Bus

Source: Transport Study of Selected Cities, Central Institute of Road Transport, Pune.

Table III 4.18

Travel parameters in different cities.

Cities	Trip length Km	PCU ('000)
Calcutta	5.8	205.9
Bombay	10.8	318.6
Delhi	13.4	508.8
Madras	7.6	91.1
Bangalore	10.6	225.9
Ahmedabad	7.3	106.7
Hyderabad	7.6	103.5
Pune	7.9	149.0
Kanpur	5.7	107.5
Madurai	2.9	48.0
Patna	3.3	51.6
Coimbatore	9.8	100.1
Vadodara	3.0	101.3
Bhopal		66.3
Cochin	3.0	34.5

Source: Transport Study of Selected Cities, Central Institute of Road Transport, Pune.

Table III.4.19
Urban energy demand projections in the passenger transport during 2001.

		Scenario 1 As per present trends					Scenario 2 As per NCU recommendations				
	Unit	Bus	Car	Two Wheeler	Three Wheeler	Total	Bus	Car	Two Wheelers	Three Wheelers	Total
Modal Split	(%)	57	9	22	12	100	80	4	10	6	100
Annual Passenger Kilometre	$(10)^8$	205	33	80	40	358	288	14	36	20	358
No. of vehicles	$(10)^3$	62	1173	7809	532	9576	87	488	3542	260	4377
PCU	$(10)^3$	186	1173	3904	532	5795	261	488	1771	260	2780
Fuel demand	(10^3toe)	1270	1012	1277	733	4292	1786	421	579	359	3145

Source: Report of the Study Group on Alternative Systems of Urban Transport, GOI, feb 1987.

Table III.4.20
Estimates of road freight traffic. (billion tonne-km)

	1961	1970	1975	1980	1981	1982	1983	1984	1985
Trucks	27.1	59.3	82.3	134.6	156.3	178	198.4	214.1	237.5
H.C.V.	26.5	57.9	80	130.8	152.1	173.4	193.2	208.2	230.9
L.C.V.	0.6	1.4	2.3	3.8	4.2	4.6	5.2	5.9	6 6
Three wheelers	**0.02**	**0.09**	**0.22**	**0.51**	**0.62**	**0.71**	**0.81**	**1.05**	**1.25**
Animal drawn carts	**2.6**	**2.9**	**3.0**	**3.2**	**3.2**	**3.3**	**3.3**	**3.4**	**3.4**
Agricultural tractors	**0.05**	**0.19**	**0.36**	**0.67**	**1.07**	**0.96**	**1.01**	**1.15**	**1.31**

Source: Engineering Consultants Pvt. Ltd., Report on "Estimation of Total Road Transport, Freight and Passenger Movement in India for the year 2000 A.D, Prepared for the Department of Surface Transport (Road Wing), GOI, January 1987.

Table III.4.21

Estimates of road passenger traffic.

(Billion passenger km)

	1961	1970	1975	1980	1981	1982	1983	1984	1985
Private motorized vehicles									
Car/taxis	12.4	21.7	30.7	42.2	44.7	48.4	54.1	59.9	64.3
2 Wheelers	0.7	3.3	7.0	15.6	18.7	21.9	26.0	30.5	35.7
3 Wheelers	0.3	1.5	3.7	7.2	8.9	9.5	10.7	12.6	14.8
Public motorized vehicles									
Buses (Total)	81.4	189.1	292.8	420.9	543.2	594.7	597.1	674.3	738.9
Buses (STUs)	24.8	72.7	118.7	203.9	225.0	248.0	263.7	276.2	292.4
Non-motorized vehicles									
Cycle-rickshaws	3.5	4.7	5.7	7.0	7.1	7.4	7.7	8.0	8.4
Bicycles	5.7	13.5	21.8	35.1	38.7	42.5	46.8	51.5	56.6

Source: Engineering Consultants Pvt. Ltd., Report on "Estimation of Total Road Transport, Freight and Passenger Movement in India for the year 2000 A.D, Prepared for the Department of Surface Transport (Road Wing), GOI,January 1987.

Table III.4.22

Estimates of occupancy of trucks and buses.

Year	Trucks Average Load (Tonnes)	Buses Occupancy Ratio (%)
1951	4.12	45
1961	4.98	59*
1971	6.01	73*
1973	6.24	72
1975	6.48	75
1976	6.60	76
1977	6.72	70*
1978	6.85	83*
1979	6.98	79
1980	7.11	77*
1981	7.25	86*
1982	7.25	86*
1983	7.25	84*
1984	7.25	84*
1985	7.25	86*

* Indicates actual data, rest are estimates.

Source: Engineering Consultants Pvt. Ltd., Report on "Estimation of Total Road Transport, Freight and Passenger Movement in India for the year 2000 A.D, Prepared for the Department of Surface Transport (Road Wing), GOI, January 1987.

Table III.4.23
Consumption of petroleum products in road transport.

Year	Petrol ('000t)	Diesel Oils ('000t)
1975/76	1275	5093.25
1976/77	1316	5182.25
1977/78	1391	5304.0
1978/79	1499	5421.25
1979/80	1490	5622.5
1980/81	1522	6252.5
1981/82	1599	6580.0
1982/83	1722	6914.0
1983/84	1891	7295.0
1984/85	2084	NA
1985/86	2275	NA
1986/87	2505	NA
1987/88	2810	NA
1988/89	3045	NA

Sources: [1] Department of Petroleum, Indian Petroleum and Natural Gas Statistics, various issues. [2] Engineering Consultants Pvt. Ltd., Report on "Estimation of Total Road Transport, Freight and Passenger Movement in India for the year 2000 A.D", prepared for the Department of Surface Transport (Road Wing), GOI, January 1987.

Table III.4.24
Intensity of various vehicles.

Vehicle	Optimum speed (Kmph)	Fuel consumption (cc/veh-km)
Scooter	-	18.7
Diesel jeep	35	69.6
Ambassador car	40	75.88
Premier Padmini car	40	71.02
Tata truck 1210 SE	45	133
Ashok Leyland Beaver truck	35	305.72
Urban bus (diesel)	-	247.1
Regional bus (diesel)	-	225.36

Sources:[1] Central Road Research Institute, Road User Cost Study in India, Final Report, 1982; and
[2] Planning Commission (GOI), Report of the National Transport Policy Committee, New Delhi, May 1980.

Table III.4.25

Fuel consumption* of different vehicles under various speeds.

	Speed (km/hr)							
	10	**30**	**35**	**40**	**45**	**70**	**90**	**100**
Diesel Jeep								
Fuel consumption (cc/km)	-	72.2	69.6	71.1	-	130.8	-	-
Fuel consumption as % of optimum	-	103.7	100.0	102.2	-	187.9	-	-
Ambassador car								
Fuel consumption (cc/km)	181.6	80.5	-	75.9	-	101.8	139.1	162.5
Fuel consumption as % of optimum	239.3	106.1	-	100.0	-	134.2	183.3	214.1
Premier Padmini car								
Fuel consumption (cc/km)	89.7	71.3	-	71.0	-	79.2	89.3	95.6
Fuel consumption as % of optimum	126.3	100.3	-	100	-	111.1	125.8	134.7
Tata truck								
Fuel consumption (cc/km)	397	153	142	135	133	162	216	-
Fuel consumption as % of optimum	298.4	115.4	106.8	106.5	100	121.8	162.4	-
Ashok Leyland Beaver truck								
Fuel consumption (cc/km)	444.8	305.9	305.7	310 3	318.7	402.8	-	-
Fuel consumption as % of optimum	145.5	100.1	100.0	101.5	104.3	131.8	-	-

* The above table gives the fuel consumption of the four vehicles when driving on a typical black-topped road on a level stretch at different speeds.

Source: Central Road Research Institute, Road User Cost Study in India,Final Report, 1982.

Water Transport

Both inland water transport (IWT) and coastal shipping have played a limited role in India. Among the most important constraints is the vintage of existing fleet of tugboats, barges, tankers and other vessels.

IWT can take place only where rivers exist. However, the rivers may not be deep and/or wide enough to allow the use of mechanized water craft. Besides, some rivers may be used by mechanized craft only during and after the rainy season. The importance of IWT has declined also with the extension of road network and with the construction of bridges to facilitate river crossings by rail and road.

Coastal shipping also operates under various constraints. Although like IWT, it entails no investment in line haul facilities, loading and unloading operations at ports have been generally slow. Some ports however, have improved considerably in recent years. The Indian merchant fleet capacity has also increased rather steadily, and it now carries about 37% of India's overall cargo traffic for international trade.

The data-base on water transport, from published sources, leaves much to be desired. Data on freight tonne-km are not available. Furthermore, from the aggregate data on cargo handled at ports, it is not possible to distinguish between cargo imports, cargo for export, and cargo for movement from one port to another along the Indian coast-line.

Besides, data on only total offtake of petroleum products for coastal shipping are available, and it is therefore difficult to estimate the energy intensity of cargo haulage. Likewise, it is also difficult to analyze the energy intensity of freight movements in shipping for international trade. However, some normative data on energy consumption intensities for various types of vessels are available.

Table III.4.26

Growth of Indian merchant fleet.

	Number of ships	**Gross registered tonnage ('000 tonnes)**
1950	177	420
1960	257	859
1965	354	1523
1970	399	2402
1971	397	2478
1972	412	2650
1973	430	2887
1974	451	3485
1975	471	3869
1976	526	5094
1977	566	5482
1978	591	5759
1979	601	5854
1980	616	5911
1981	620	6020
1982	644	6213
1983	677	6227
1984	710	6415
1985	741	6605
1986	736	6540
1987	803	6726
1988	797	6161
1989	834	6315
1990	855	6476

Source: Centre for Monitoring Indian Economy (CMIE), Basic Statistics relating to the Indian Economy, vol. I, All India, various issues.

Table III.4.27

Shipping cargo handled at major ports [a] (million tonnes)

	1950/51	1960/61	1970/71	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1987/88**	1988/89*
Bombay	7.0	14.7	14.4	17.6	19.6	24.8	25.4	25.2	24.9	23.6	21.5
Calcutta & Haldia	7.6	9.5	6.0	9.3	9.8	10.5	10.9	10.2	12.1	10.6	10.0
Cochin	1.4	2.1	4.8	5.2	5.5	5.7	5.6	3.9	5.1	5.6	5.8
Kandla	-	1.6	1.6	8.8	9.5	12.6	13.7	15.7	16.5	14.9	13.1
Madras	2.2	3.0	6.9	10.4	11.4	12 4	12.8	15.0	18.2	19.2	18.3
Murmugao	-	-	11.0	13.9	14.9	12.8	12.8	14.5	16.1	9.5	9.8
New Mangalore	-	-	-	1.0	1.6	2.3	3.1	3.4	3.7	4 8	5.3
Paradip	-	-	2.2	2.3	2.2	1.6	1 6	2 1	3 3	4.3	4.6
Tuticorin	-	-	-	2.6	2.7	3 2	3.6	3.8	4.2	3 4	3 7
Vishakapatnam	1.0	2.9	8.8	10.2	10.9	10 2	11 1	12 9	15.9	12.7	14.8
Total	**19.2**	**33.8**	**55.7**	**81.3**	**88.1**	**96.1**	**100.6**	**106.7**	**120.0**	**124.4**	**146.4**

[a] Account for nearly 90% of total cargo handled at all ports.

* Up to January end.

** Up to December 1988.

Sources: [1] Centre for Monitoring Indian Economy (CMIE), Basic Statistics relating to the Indian Economy vol I All India various issues and [2] Ministry of Surface Transport, GOI, Annual Report, various issues.

Table III.4.28
Self reliance in moving cargo on Indian ships.

Year	**Share of Indian ships in overall overseas cargo traffic (%)**
1955/56	6.5
1960/61	9.0
1965/66	12.9
1970/71	19.8
1975/76	35.1
1980/81	32.3
1981/82	31.4
1982/83	41.5
1983/84	40.9
1984/85	37.1
1985/86	34.7
1986/87	37.0
1987/88	41.0
1988/89	34.9
1989/90	36.0
1990/91	37.0

Source: Centre for Monitoring Indian Economy (CMIE), Basic Statistics relating to the Indian Economy, vol. I All India, various issues.

Table III.4.29

Commodity composition of traffic at major ports.

	1960/61	1970/71	1975/76	1979/80	1988/89	1989/90	1990/91
Petroleum (%)	0.4	33.0	32.9	37.2	43.8	43.3	43.1
Iron Ore (%)	16.9	35.2	32.3	29.9	22.6	21.3	20.9
Coal (%)	5.5	1.3	1.8	2.5	11.0	10.7	13.0
Fertilizers (%)	1.6	4.3	5.2	7.7	3.4	4.0	5.1
Other Cargo (%)	45.6	26.2	27.2	23.1	19.2	18.2	17.9
Total (MT)	**39.5**	**55.7**	**65.4**	**78.0**	**146.0**	**148.14**	152.55

Sources: [1] Planning Commission (GOI), Report of the National Transport Policy Committee, New Delhi, May 1980; [2] CMIE, Basic Statistics relating to the Indian Economy, vol.I All India, various issues;and [3] Ministry of Surface Transport, GOI, Annual Report, various issues.

Table III.4.30

Fuel deliveries made to coastal and international bunkers.

('000 tonnes)

	1970/71	1976/77	1979/80	1982/83	1985/86	1988/89	1989/90
Coastal Bunkers	**240.9**	**211.3**	**196.7**	**301.0**	**305.9**	**372.6**	**367.1**
Furnace oil	196.9	153.1	126.4	172.2	167.7	200.0	208.4
High speed diesel	22.4	32.2	41.9	81.0	98.3	134.3	120.7
Light diesel oil	21.6	26.0	28.4	47.8	39.9	38.3	38.0
International bunkers	**234.3**	**237.2**	**216.6**	**141.2**	**105.9**	**147.7**	**143.2**
Furnace oil	207.9	166.9	135.8	85.0	64.3	101.9	143.2
High speed diesel	6.4	19.9	17.7	14.5	10.1	7.2	8.6
Light diesel oil	20.0	50.4	63.1	41.7	31.5	38.6	36.0

Source: Department of Petroleum, and Natural Gas, Annual Petroleum & Natural Gas Statistics, 1989-90, GOI, New Delhi.

Table III.4.31
Intensity of water traffic. (kgoe/t-km)

	Intensity	Remarks
Inland water transport		
1000 tv	0.00677	50% lf
1000 tv	0.00432	75% lf
1500 tv	0.00449	50% lf
1500 tv	0.00289	75% lf
Coastal Shipping		
14400 tv	0.00373	Cargo : Coal
14400 tv	0.00435	Cargo : Salt

tv: Ton Vessel
lf: Load Factor
Source: Planning Commission, Report of the National Transport Policy Committee, New Delhi, May 1980.

Air transport

India's three air carriers are Air India (international), the Indian Airlines (domestic) and Vayudoot (domestic). The Indian Airlines also operates on some medium distance international routes to some Asian countries.

The air carriers are still not a major form of transport either for passenger or for freight traffic in India; although beginning from a small base, air traffic has grown very rapidly since the early seventies.

Relevant information is available only for the Indian Airlines, which is the premier air carrier operating on domestic routes. Its fleet composition and capacity have changed significantly during the past fifteen years or so; a distinct trend is observed towards larger jet-engined aircraft. The share of passenger traffic carried through the latter aircraft has also increased rapidly. Consequently, the overall energy intensity has reduced. According to an estimate made by the Indian Airlines, the intensity reduced from 0.083 litres of ATF per available seat-km (lit/as-km) in 1970/71, to about 0.049 lit/as-km in 1982/83.

However, it is difficult to estimate energy intensity of the Indian Airlines from published sources. Data on ATF offtakes by the Indian airlines alone are seldom published. Only the total ATF offtakes by all three India's air carriers as well as by international airlines and other air services are available.

Table III.4.32
Indian Airlines -- revenue flying hours.

Year	Total	A300B	Boeing 737	Others
1972/73	116077	-	17950	98127
1973/74	83501	-	13413	70088
1974/75	95105	-	17648	77457
1975/76	106189	-	30142	76047
1976/77	107156	2306	33975	70875
1977/78	106378	7929	34910	63539
1978/79	114391	11046	40847	62498
1979/80	106409	14157	35929	56323
1980/81	105703	16722	41717	47264
1981/82	104248	20267	44806	39175
1982/83	106662	23301	52182	31179
1983/84	109448	22778	60222	26448
1984/85	118910	24740	66919	27251
1985/86	127479	26908	72144	28427
1986/87	134511	30154	78690	25667
1987/88	136449	31087	84327	21035
1988/89	124067	30972	79760	13335
1989/90	117649	29397	74707	13563

Source : Indian Airlines, Annual Report, various issues.

Table III.4.33
Air -- passenger traffic.

	1975/76	1980/81	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Revenue passenger carried ('000)	**3367.3**	**5428.0**	**8544.0**	**9172.8**	**9907.8**	**10470.6**	**10109.7**	**9848.9**
Indian airlines (domestic)	3240.5	5079.7	8082.7	8637.8	9352.6	9910.5	9545.6	9409.5
Indian airlines (international)	118.7	328.2	426.4	491.9	522.2	529.6	564.1	439.5
Air India (domestic)	8.1	20.1	34.9	43.1	33.0	30.5	-	-
Revenue passenger km(million) (Indian airlines Only)	**2609.2**	**4323.1**	**6676.5**	**7336.4**	**8036.3**	**8665.9**	**8677.8**	**8622.1**

Source : Indian Airlines, Annual Report, Various issues.

Table III.4.34
Occupancy Ratio (Indian Airlines).

Year	**Available Seat-km (million)**	**Revenue Passenger-km (million)**	**Occupancy Ratio (%)**		
			All Types	**A 300B**	**Boeing 737**
1972/73	3479.0	2167.2	62.3	-	66.2
1973/74	2700.7	1904.4	70.5	-	69.0
1974/75	3216.2	2229.8	69.3	-	63.5
1975/76	3870.6	2609.2	67.4	-	64.4
1976/77	4128.8	2926.8	70.9	70.0	69.2
1977/78	4806.5	3388.8	70.5	71.2	67.9

contd...

Table III.4.34 (contd.)
Occupancy Ratio (Indian Airlines).

Year	Available Seat-km (million)	Revenue Passenger-km (million)	Occupancy Ratio (%)		
			All Types	A 300B	Boeing 737
1979/80	5720.3	4199.1	73.4	76.8	68.6
1980/81	6466.1	4323.1	66.9	70.4	63.5
1981/82	7127.7	4902.6	68.8	69.8	67.7
1982/83	7965.4	5408.2	67.9	69.2	66.3
1983/84	8252.7	5994.3	72.6	76.8	69.3
1984/85	9042.9	6676.5	73.8	78.2	70.4
1985/86	9924.2	7336.4	73.9	79.1	69.8
1986/87	10897.1	8036.3	73.7	78.4	69.8
1987/88	11347.5	8665.9	76.4	81.6	71.7
1988/89	10773.8	8677.8	80.5	85.1	76.2
1989/90	11252.1	8622.1	76.6	80.4	73.0

Source : Indian Airlines, Annual Report, Various issues.

Table III.4.35

Cargo and mail carried by Indian Airlines.
('000 tonnes)

Year	Cargo carried*	Mail Carried	Total
1972/73	26.6	14.1	40.7
1973/74	19.6	11.0	30.6
1974/75	20.0	11.4-	31.4
1975/76	24.3	12.6	36.9
1976/77	28.2	12.9	41.1
1977/78	37.6	13.6	51.2
1978/79	48.6	14.6	63.2
1979/80	50.9	14.6	65.8
1980/81	58.3	15.7	74.0
1981/82	69.8	16.4	86.2
1982/83	77.9	16.1	94.0
1983/84	94.1	17.1	111.2
1984/85	109.5	17.7	127.2
1985/86	111.2	18.3	129.5
1986/87	117.0	17.8	134.8
1987/88	127.5	17.7	145.2
1988/89	129.6	17.3	146.9
1989/90	118.1	16.6	134.7

* Includes excess baggage.

Source: Indian Airlines, Annual Report, Various Issues.

Table III.4.36

Aircraft utilization per annum (total hours).

	A-300B	A-320	Boeing-737	All types
1980/81	2531	--	2759	2441
1981/82	2547	--	2505	2381
1982/83	2555	--	2567	2486
1983/84	2477	--	2652	2429
1984/85	2624	--	2761	2563
1985/86	2733	--	2970	2700
1986/87	2887	--	3054	2797
1987/88	2872	--	3185	2908
1988/89	2964	--	3062	2879
1989/90	2901	2080	2607	2603

Source: Indian Airlines, Annual Report, Various issues.

Table III.4.37

ATF Offtake. ('000 tonnes)

Year	Offtake
1970/71	689
1979/80	1144
1982/83	1145
1983/84	1208
1984/85	1336
1985/86	1453
1986/87	1603
1987/88	1654
1988/89	1713
1989/90	1775
1990/91	1690

Source: Department of Petroleum and Natural Annual Petroleum & Natural Gas Statistics 1989-90, GOI, New Delhi.

Table III.4.38

Energy intensities of various aircraft.

	Intensity (litre/available seat-km)	Available Seats
Airbus	0.042	278
Boeing 737	0.055	126
Turbo	0.075-0.080	<100

Source: Planning Commission (GOI), Report of the National Transport Policy Committee, New Delhi, May 1990.

Residential sector

Energy consumption mix

The residential sector is the largest consumer of energy, accounting for approxi 40% [CMIE, 1990] of the energy consumption in the country. A large fraction energy used in households comprises traditional fuels, such as fuelwood, anima and crop residues. The data base is therefore quite inadequate, although some ind data, gathered through field surveys, are available. The data presented in survey ı are not based on actual measurements, but solely on the "impressions" of the qı used.

Therefore, the information thus gathered may be considered to be onl qualitative nature. But it also gives considerable insight regarding the consumption pattern in households. Field surveys to date have indicated broadl (i) per capita energy consumption increases with a rise in income and expen levels; and (ii) the share of commercial energy in the total consumption mix inc with income and expenditure levels, as also with the size of town and city. Ho the rise in per capita energy consumption with expenditure levels is shown relatively more in urban areas. This may reflect the fact that a significantly proportion of energy used in rural areas may be collected at zero private cost, a p which is normally not possible in urban areas.

Not only are there significant urban-rural differences in how energy suppli households are obtained, but also how energy is consumed. The energy consum mix itself may change over time. Some of these aspects and energy demand proje are highlighted in subsequent sections.

Table III.5.1

Index of per-capita energy consumption.

For 1973-74 * **monthly per-capita expenditure class (Rs.)**	**Rural**	**Urban**
< 21	66	48
21 - 28	80	61
28 - 43	90	82
43 - 75	101	96
> = 75	138	125
All classes	**100**	**100**
For 1978-79 **		
Annual household income category (Rs.)		
= < 3000	98	86
3001 - 6000	96	95
6001 - 12000	112	113
12001 - 18000	125	134
> 18000	127	133
All classes	**100**	**100**

** **Source**: National Council for Applied Economic Research, Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi, 1981.

* **Source**: National Sample Survey 1973/74, 28th Round; as quoted in Govt. of India, Report of the Working Group on Energy Policy, New Delhi, 1979.

Table III.5.2
Fuel-mix across income groups (percentage share in terms of 'useful' energy).

	Income groups (Rs. per annum per household)					
	Up to 3000	3000-6000	6000-12000	12000-18000	18000+	All
Rural						
Softcoke	1.3	1.6	4.7	4.9	7.3	2.1
Kerosene	2.7	2.6	2.3	1.8	1.8	2.6
Electricity	0.2	0.4	0.6	0.9	1.0	0.4
Firewood	60.8	59.0	56.8	53.5	49.3	59.2
Veg. waste	16.1	14.6	15.6	18.2	16.6	15.6
Dung cake	18.9	21.8	20.0	20.7	24.0	20.1
Commercial	4.2	4.6	7.6	7.6	10.1	5.1
Non-commercial	95.8	95.4	92.4	92.4	89.9	94.9
Urban						
Softcoke	14.9	23.6	31.1	20.0	19.8	23.2
kerosene	19.4	23.8	19.6	17.7	14.8	21.1
Electricity	0.8	1.7	2,.6	3.5	4.9	1.9
LPG	-	5.2	15.9	34.0	41.3	9.8
Firewood	54.9	37.3	22.8	16.7	13.9	35.5
Veg. waste	2.6	1.4	1.4	2.7	1.1	1.7
Dung cake	5.2	4.5	3.9	4.1	2.3	4.5
Charcoal	2.2	2.5	2.7	1.3	1.5	2.3
Commercial	37.3	56.8	71.9	76.5	82.7	58.3
Non-commercial	62.7	43.2	28.1	23.5	17.3	41.5

Source: National Council for Applied Economic Research, Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi, 1981.

Table III.5.3

Estimates of annual per-capita energy consumption in rural areas.

	Units	1962[a]	1963/64[a]	1973/74[a]	1978/79[b]
Commercial fuels					
Coal/Soft coke	kg	3.8	5.2	6.8	2.3
Kerosene (total)	**litre**	**5.8**	**4.4**	**8.8**	**5.1**
for lighting	litre	NA	NA	NA	4.3
for cooking[c]	litre	NA	NA	NA	0.8
LPG	kg	---	---	---	0.01
Electricity	kWh	0.5	0.3	2.2	4.9
Traditional fuels					
Fuelwood	kg	234.7	270.1	251.9	40.9
Charcoal	kg	0.6	0.7	0.1	0.2
Dungcake	kg	126.8	100.8	72.7	133.1
Other solid fuels[d]	kg	72.3	9.8	12.4	176.9

[a] As quoted in Ashok V.Desai, Inter-Fuel Substitution in the Indian Economy, Discussion Paper D-73 B, Resources for the Future, Washington, D.C., 1981.

[b] National Council for Applied Economic Research, Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi, 1981.

[c] Also includes water heating and space heating.

[d] Includes crop wastes, sawdust, woodshaving, twigs, leaves etc.

Note: 'Fuelwood' and 'Other Solid Fuels' may be clubbed together in order to facilitate a comparison of estimates of per-capita non-commercial energy consumption.

Table III.5.4

Estimates of annual per-capita energy consumption in urban areas.

	Units	1963/64[a]	1973/74[a]	1978/79[b]
Commercial fuels				
Coal/soft coke	kg	29.8	33.4	31.3
Kerosene (total)	**litre**	**10.2**	**14.0**	**11.6**
for lighting	litre	NA	NA	2.6
for cooking[c]	litre	NA	NA	9.0
LPG	kg	---	---	2.2
Electricity	kWh	9.0	18.2	35.0
Traditional Fuels				
Fuelwood	kg	169.3	148.6	82
Charcoal	kg	4.4	2.6	3.8
Dung cakes	kg	33.3	25.2	35.7
Other solid fuels[d]		kg	3.5	4.9

[a,b,c,d]: Refer to Table III.5.3.

Note: 'Fuelwood' and 'Other Solid Fuels' may be clubbed together in order to facilitate a comparison of estimates of per-capita non-commercial energy across the years.

Table III.5.5

Estimates of annual per-capita energy consumption in metropolitan cities.

	Units	Delhi 1958	Calcutta 1958[a]	Bombay 1958[a]	Bombay 1972[b]	Delhi 1978/79
Commercial fuels						
Coal/Soft coke	kg	54.6	84.0	26.7	3.0	67.7
Kerosene (total)	litre	8.9	8.6	31.1	34.3	19.0
for lighting	litre	2.5	4.5	2.9	NA	0.2
for cooking[c]	litre	6.4	4.1	28.2	NA	18.8
LPG	kg	-	-	-	8.8[d]	5.7
Electricity (total)	**kWh**	**52.3**	**53.7**	**37.9**	**108.5**	**90.6**
for lights and fans	kWh	29.0	41.3	29.5	NA	61.0[e]
for other uses	kWh	23.3	12.4	8.4	NA	29.6
Traditional fuels						

contd...

Table III.5.5 (contd.)

Estimates of annual per-capita energy consumption in metropolitan cities.

	Units	Delhi 1958	Calcutta 1958 [a]	Bombay 1958 [a]	Bombay 1972 [b]	Delhi 1978/79
Fuelwood	kg	18.7	28.8	28.7	9.7	6.7
Charcoal	kg	10.9	2.47	2.7	6.0	-
Dungcake	kg	14.4	6.7	0.6	f	1.9
Other solid fuels[g]	kg	NA	8.9	0.8	7.0	12.3

[a] Survey done during summer months.

[b] Survey done in an unspecified month.

[c] Also includes water heating and space heating.

[d] In cubic metres.

[e] For lighting only.

[f] Included in other solid fuels.

[g] Comprises crop wastes, straw, twigs, leaves etc.

Source: For Delhi (1978-79), National Council for Applied Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi, 1981; For Others, as quoted in Ashok V. Desai (1981), Inter-Fuel Substitution in the Indian Economy, Discussion Paper D-73 B, Resources for the Future, Washington D.C.

Table III.5.6

Per capita consumption of energy by size of town and by type of fuel.

	Over 5 lakhs	2-5 lakhs	1-2 lakhs	0.5-1 lakhs	0.2-0.5 lakhs	Up to 0.2 lakhs
All fuels (kgcr*)	294	275	269	263	243	243
% Non-comm. energy (%)	24.59	33.84	42.52	44.43	62.48	60.94
% Comm. energy (%)	75.41	66.16	57.48	55.57	37.57	39.06
Firewood (%)	17.65	20.67	29.64	31.82	38.56	32.92
Soft coke (%)	17.29	14.24	21.31	22.48	18.84	14.32
Kerosene (%)	28.87	28.62	19.76	18.74	9.51	16.57
Electricity (%)	13.47	9.37	9.22	8.00	6.32	6.67
LPG(%)	15.58	12.7	7.19	6.35	2.89	1.47
Others (%)	7.41	14.4	12.88	12.61	23.88	28.15

* kgcr: kilogram of coal replacement.

Source: TERI, Report on Energy in the Context of Urbanisation, prepared for the National Commission of Urbanisation, Ministry of Urban Development, New Delhi, August 1987.

Shifts in energy consumption mix

Changes in energy consumption over time are determined by several factors including family size, fuel availability, relative prices of various fuels, and so on.

The NCAER collected some information to establish the broad trends in energy consumption during the five year period 1974/75 to 1978/79. The data that are available relate only to the number of households using a particular type of fuel, and not to the actual or estimated quantities of fuels used. The available data indicate a distinct shift away from firewood in both urban and rural areas. While the fraction of households using LPG increased substantially in urban areas, in rural areas the use of biogas increased. The fraction of households using soft-coke also is shown to have increased gradually from 1974/75 to 1978/79, in both rural and urban areas.

Further information on fuel shifts in urban households between 1978/79 and 1983/84 is also available. The trend of a decline in the use of firewood is clearly evident. However, the use of soft- coke is also reported to have declined, but this may be due to its decreasing supplies. The use of kerosene and LPG is shown to have increased substantially; the latter, particularly in the high expenditure category households.

Despite these shifts, there is little evidence that households now use the fuel they prefer for cooking. High cost or/and inadequate availability are perhaps the most important reasons for using a fuel which may not be preferred. A rise in income however, is revealed to be the most significant reason for shifting to commercial fuels for cooking.

Table III.5.7

Break-up of households as per cooking fuel.

(% of households)

	Coal/soft-coke	Kerosene	Firewood	LPG	Gobar gas	% of household for which data are not available
Rural areas						
1974		6.82	64.19	0.77	-	28.22
1979	4.92	5.13	9.64	0.70	37.13	42.48
Urban areas						
1974	26.57	10.88	47.01	4.04	-	11.50
1979	30.47	16.76	7.86	32.16	0.20	12.55

Source: National Council for Applied Economic Research, Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi,1981.

Table III.5.8

Incomewise fuel shares (%) for cooking and heating.

Income		Low (< 3000)	Low-middle (3000-6000)	Middle (6000-12000)	High-middle (12000-18000)	High (>=18000)	All
Firewood	1978/79[a]	60	40.9	25.1	17.4	12.1	42.4
	1983/84[b]	53.5	30.8	17.9	9.9	9.6	27.4
Soft coke	1978/79	12.8	20.2	23.6	16.7	17.3	18.4
	1983/84	6.4	18	17.9	15.2	8.3	15.3
Kerosene	1978/79	13.2	21.3	21.5	22.0	18.9	18.7
	1983/84	23.8	36.9	40.2	38.2	32.8	35.7
LPG	1978/79	0.8	4.6	14.2	26.9	32.9	6.6
	1983/84	1.2	4.6	15.7	27.9	39.3	11.5
Other	1978/79	13.3	13.1	15.6	17.0	18.8	13.9
	1983/84	15.2	9.7	8.3	8.8	10.1	1.01
No. of households ('000)	1979	7286	9895	4792	611	524	23108
	1984	4885	9298	9742	2598	1193	27716

[a] Income categories are in thousands 1978-79 rupees per year.

[b] Shares are on a coal replacement basis for cooking and heating.

Source: TERI, Report on Energy in the Context of Urbanisation, prepared for the National Commission of Urbanisation, Ministry of Urban Development, New Delhi, August 1987.

Table III.5.9

Reasons for not using preferred fuel for cooking (% of Households).

Preferred fuel	Reason for not using preferred fuel			% of households not using preferred fuel, prefer*
	Costly	Not easily available	others	
Rural				
Soft coke	34.01	57.92	8.07	19.65
Kerosene	66.74	33.17	0.09	17.27
Electricity	79.70	-	20.30	1.80
Firewood	25.26	60.88	13.86	14.20
LPG	19.20	78.25	2.55	29.19
Urban				
Soft coke	48.60	31.49	19.91	6.61
Kerosene	69.71	29.70	0.59	7.71
Electricity	72.49	13.63	13.88	1.62
Firewood	67.97	7.93	24.10	2.32
LPG	18.86	74.58	6.56	78.51

* May not add up to 100, because several other fuels are also used in certain households.

Source: National Council for Applied Economic Research, Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi, 1981.

Table III.5.10

Reasons for shifting to present* fuel for cooking - All India (% of households).

	Rise in income	Fall in income	Present fuel has become cheaper	Present fuel not available 5 yrs ago	Present fuel is more easily available	Other reasons	Total
Rural							
Soft coke	72.63	-	15.59	11.78	-	-	100
Kerosene	30.91	-	9.64	-	59.45	-	100
Electricity	-	-	-	-	-	-	-
Firewood	91.79	-	8.21	-	-	-	100
LPG	66.67	-	-	33.33	-	-	100
All fuels	20.04	9.30	4.68	12.71	15.09	38.18	100
Urban							
Soft coke	17.81	3.51	28.18	11.96	18.05	20.49	100
Kerosene	49.91	8.24	2.27	12.74	5.15	21.69	100
Electricity	100.0	-	-	-	-	-	100
Firewood	4.67	22.69	-	-	12.08	60.56	100
LPG	36.7	-	4.83	35.27	13.24	9.96	100
All fuels	30.69	4.23	11.03	19.33	13.39	21.33	100

* Present refers to the year 1978-79.

Source: National Council for Applied Economic Research, Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi, 1981.

End uses

While traditional energy fuels are normally used for cooking, water-heating and space-heating, commercial energy forms may be used for lighting, cooking and running other appliances (such as refrigerators, television sets etc.) as well. At the aggregate, all India level, the survey conducted by the NCAER reveals that in 1978/79, the share of total energy used for cooking, water heating and space-heating decreased with a rise in income levels in both rural and urban areas.

For commercial energy sources alone, their respective shares for these same end-uses increased with income levels in rural households; although no such trend was evident in urban households.

Furthermore, it is important to note that the total energy consumption data itself may not be a useful indicator, and that the "useful energy" consumption is more relevant. However, the latter may be determined only by measuring the efficiencies of various household appliances. In the absence of such measurements, some normative average efficiency figures (Table III.5.13) may be used.

Table III.5.11

Use of commercial energy for cooking and lighting in rural & urban areas in 1978/79.

Annual household income category (Rs)	Rural			Urban		
	Total ('000 tcr)	% for cooking	% for lighting	Total ('000 tcr)	% for cooking	% for lighting
0-3000	4190.971	33.7	66.3	2820.353	78.3	21.7
3001-6000	3521.332	41.3	58.7	8059.603	84.6	15.4
6001-12000	1946.745	52.7	47.3	7230.658	86.5	13.5
12001-18000	326.466	55.2	44.8	1369.735	86.0	14.0
>=18000	307.388	61.2	38.8	1488.129	84.8	15.2

Note 1: Cooking includes water heating and space heating. Lighting includes the use of fans, refrigerators, television sets and other electrical appliances.

Note 2: All Commercial energy consumption for the two end-uses is first expressed in 'mtcr' units. Only then is it possible to estimate the percentage of commercial energy use in the two major end-uses.

Source: National Council for Applied Economic Research, Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi, 1981.

Table III.5.12

Use of commercial and traditional energy for cooking and lighting in rural and urban areas in 1978/79.

Annual household income category (Rs)	Rural			Urban		
	Total ('000 tcr)	% for cooking	% for lighting	Total ('000 tcr)	% for cooking	% for lighting
0-3000	45780.912	90.4	9.6	8316.976	87.2	12.8
3001-6000	31963.919	89.5	10.5	14664.046	85.1	14.9
6001-12000	14170.641	88.8	11.2	10350.890	82.7	19.6
12001-18000	2265.293	88.3	11.7	1777.074	80.4	19.6
>=18000	1799.243	88.2	11.8	1757.413	77.0	23.0

Source: National Council for Applied Economic Research, Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi, 1981.

Table III.5.13
Average efficiency of utilization of cooking fuels (%).

Commercial fuels	
Soft coke/coal	10
Kerosene (in pressure stove)	56
Kerosene (in wick stove)	42
LPG	63
Non-commercial fuels	
Firewood (in closed hearth)	16
Firewood (in open hearth)	13
Twigs and straw (in closed hearth)	16
Twigs and straw (in open hearth)	13
Charcoal	16
Dungcake	8

Source: NCAER, Energy Demand in Greater Bombay. New Delhi, 1975.

Published data on residential energy consumption

As noted in the first section, information on household energy consumption patterns is available only from sample surveys, which may not be too reliable, considering that all surveys suffer from a major drawback that energy use is not actually measured while conducting the survey. Therefore, it becomes relevant to compare the data available from field surveys, with official estimates of energy sales to households. Of course, such a comparison is possible only for commercial energy forms: soft coke, kerosene and electricity.

The findings of three surveys may be compared with official estimates of energy consumption. It may be observed that while the surveys in 1963/64 and 1973/74 underestimated electricity consumption substantially, the survey in 1978/79 overestimated the use of soft coke. There seems to be a fair measure of agreement in the utilization of other fuels. With this observation, it becomes clear that survey estimates for utilization of traditional fuels may at best be considered to provide only qualitative information.

Likewise, production data for household appliances/devices are also available. Again, such data may not reveal exactly the population of appliances used in households because of three reasons : (i) available data may not include the production/

output of certain small manufacturers; (ii) a certain unknown fraction of the population of devices may in reality be used in commercial establishments; and (iii) the useful life span of many of these appliances may be difficult to determine.

Table III.5.14

Total annual commercial energy consumption -- a comparison of survey estimates.

	Units	1963/64	1963/74	1978/79
Survey estimates				
Soft coke	'000 t	2081	3285	5483
Kerosene	'000 t	2381	4674	3376
Electricity	GWh	883	3147	7317
Official estimates [a]				
Soft coke	'000 t	2279	2911	2680
Kerosene	'000 t	2437	3451	3312
Electricity	GWh	2062	4645	7577

[a] Based on production and sales data.

Sources: For survey estimates, 1963-64 and 1973-74: As quoted in Ashok V. Desai (1981), Inter-Fuel Substitution in the Indian Economy, Discussion Paper D-73 B, Resources for the Future, Washington D.C., 1981; for 1978-79: Survey Estimates NCAER,Domestic Fuel Survey with Special Reference to Kerosene (1978/79), New Delhi, 1981; and for official estimates from:

[1] Deptt. of Petroleum, Indian Petroleum and Petrochemical Statistics, G.O.I., New Delhi

[2] CEA, Public Electricity Supply: All India Statistics--General Review, New Delhi; and

[3] Coal Controller's Organisation, All India Annual Coal Statistics, Calcutta, various issues.

Table III.5.15
Official estimates for commercial energy consumption.

	LPG (mt)	Kerosene (mt)	Electricity (GWh)
1972/73	NA	3.492	4309.01
1973/74	NA	3.300	4644.55
1974/75	NA	2.895	5172.79
1975/76	0.266	3.104	5821.35
1976/77	0.27	3.322	6336.56
1977/78	0.29	3.634	6821.31
1978/79	0.302	3.952	7575.66
1979/80	0.332	3.872	8402.23
1980/81	0.327	4.228	9246.43
1981/82	0.424	4.693	10439.62
1982/83	0.53	5.214	12091.63
1983/84	0.66	5.524	13234.51
1984/85	0.854	5.959	15505.72
1985/86	1.100	6.229	17257.83
1986/87	1.341	6.645	19268.58
1987/88	1.415	7.231	16116.00
1988/89	1.960	7.730	15430.04
1989/90	2.270	8.240	N.A

Sources: [1] Deptt. of Petroleum, Indian Petroleum and Petrochemical Statistics, G.O.I., New Delhi
[2] CEA, Public Electricity Supply: All India Statistics--General Review, New Delhi.

Table III.5.16

Production of selected household appliances ('000).

	1970	1975	1980	1983	1985	1986
Incandescent lamps	10300	12900	20100	27200	27100*	28400*
Electric fans	1570	1310	4120	4610	5200*	4700
TV sets	5.1	39.4	86.8	155	2480**	3000**
Refrigerators	65.4	108.9	278.0	465.2	677.6*	591.4*
Portable room air-conditioners	17	9.0	26.2	26.9	31.0	39.5

* Data refers to financial year.

** Production of large, medium and small scale units.

Source: Centre for Monitoring Indian Economy, Production and Capacity Utilization in 600 industries (1970 to 1986), October, 1987.

Data based on TERI survey

Based on the survey of five different regions viz. North, South, East, West and Central, the results were compiled. The cities chosen to represent the above mentioned regions were - Delhi, Sahibabad, Jaipur, Sangner, Madras, Tambaram, Choudwar, Baranga, Jabalpur and Nainpur. Total household energy demand was estimated for the years 1991 and 2001 by adding up the gross product of total per capita fuel consumption in different income classes with the corresponding share of population belonging to each income group. Distribution of urban population (excluding slum population) across different income categories is worked out on the basis of the population distribution over various expenditure categories for the year 1986-87 [NSSO, 1989] and the savings rate in the corresponding expenditure classes [NCAER, 1985].

Table III.5.17

Incomewise per capita annual consumption of different fuels _ all India urban.

(MJ)

Income class in rupees	**LPG**	**Kero-sene**	**Soft coke**	**Firewood**	**Dung cake**	**Electricity**	**All together**		**Efficien of utilizatic (%)**
							Gross	**Useful**	
Upto 500	227 (5.2)	675 (15.3)	134 (3.0)	2552 (57.8)	419 (9.5)	405 (9.2)	4412 (100)	1313	(30)
500-1000	553 (12.4)	715 (15.9)	286 (6.4)	2249 (50.3)	211 (4.7)	460 (10.3)	4474 (100)	1547	(35)
1000-1500	828 (17.9)	642 (13.9)	413 (8.9)	1801 (38.9)	275 (5.9)	669 (14.5)	4628 (100)	1855	(40)
1500-3000	1370 (35.7)	474 (12.4)	118 (3.1)	653 (17.0)	24 (.6)	1196 (31.2)	3835 (100)	2373	(62)
3000-4500	1970 (46.7)	193 (4.6)	18 (.4)	219 (5.2)	5 (.1)	1817 (43.0)	4222 (100)	3130	(74)
4500-6000	2113 (43.6)	182 (3.8)	20 (.4)	281 (5.8)	177 (3.6)	2071 (42.8)	4844 (100)	3494	(72)
Over 6000	2111 (35.1)	120 (2.0)	- (2.5)	149 ~~(60.4)~~ ?	- ~~(100)~~ ?	3635 (60.4)	6015 (100)	4982	(83)
All together	**1285** **(29.8)**	**469** **(10.9)**	**166** **(3.8)**	**1041** **(24.2)**	**115** **(2.7)**	**1235** **(28.6)**	**4311** **(100)**	**2433**	**(56)**

Figures in parentheses denote percentage values.

Table III.5.18
percentage share of energy consumption for different end-uses by income categories - all India urban.

Income class in rupees	Cooking	Water heating	Space heating	Space cooling	Lighting	Others
Upto 500	78.9	9.8	-	2.6	6.3	2.4
500-1000	78.5	9.1	0.1	3.0	6.1	3.2
1000-1500	72.7	10.4	0.4	4.4	7.4	4.7
1500-3000	61.3	7.9	0.8	7.9	12.4	9.7
3000-4500	52.2	8.5	1.3	12.1	13.7	12.2
4500-6000	50.9	11.7	1.6	11.1	13.9	10.8
Over 6000	36.7	13.5	6.3	12.0	19.8	11.7
All together	**62.1**	**9.7**	**1.1**	**7.5**	**11.3**	**8.3**

Table III.5.19
Percentage share of energy consumption across different end-uses - all India urban.

Income class in rupees	Cooking	Water heating	Lighting	Space cooling	Space heating	Others
LPG	96.29	3.71	-	-	-	-
Kerosene	71.24	20.58	8.18	-	-	-
Soft coke	90.76	9.24	-	-	-	-
Firewood	85.62	14.38	-	-	-	-
Dungcake	82.14	17.86	-	-	-	-
Electricity	1.00	7.60	34.69	25.27	3.79	27.60

Table III.5.20

Percentage share of fuel mix pattern for different end-uses - All India Urban.

Income class in rupees	Cooking	Water heating	Lighting	Space heating	Space cooling	Others
LPG	47.07	11.60	-	-	-	-
Kerosene	12.55	23.21	7.90	-	-	-
Soft coke	5.01	3.27	-	-	-	-
Firewood	31.55	33.93	-	-	-	-
Dungcake	3.21	4.46	-	-	-	-
Electricity	0.51	23.50	92.10	100.00	100.00	100.00

Table III.5.21

Household energy consumption in selected cities.

Cities/towns	Population (thousand)	Useful annual per capita total energy consumption (MJ)	Annual per capita electricity consumption (kWh)
Delhi	5729	1193	612.0
Madras	4289	1137	340.0
Pune	1685	1008	129.6
Jaipur	1015	1010	330.0
Jabalpur	757	1083	256.0
Solapur	514	802	147.6
Nanded	191	788	98.4
Satara	84	922	117.6
Srirampur	55	842	110.4
Talegam	22	821	62.4
Junnar	18	1092	68.4

Table III.5.22

Energy demand projections in urban households.

Income class in rupees	Distribution of households (%)	All India urban population - excluding slums (million)		Annual per capita consumption norms					
		1991	2001	LPG (kg)	Kero-sene (kg)	Soft coke (kg)	Firewood (kg)	Dungcake (kg)	Electri-city (kWh)
Upto 500	2.54	4.09	5.80	5.01	14.71	6.39	129.23	47.01	112.39
500-1000	47.44	76.38	108.26	12.24	15.58	13.64	113.88	23.64	127.78
1000-1500	27.58	44.40	62.94	18.32	13.98	19.72	91.21	30.86	185.81
Over 1500	22.44	36.13	51.21	36.04	7.79	3.72	24.50	3.80	445.73
All together	-	**161.00**	**228.00**	-	-	-	-	-	-

Table III.5.22

Energy demand projections in urban households (continued).

Income class in rupees	Total requirement in 1991						Total requirement in 2001					
	LPG (mt)	Ker. (mt)	S.cok (mt)	F.wood (mt)	D.cake (mt)	Elect. (tWh)	LPG (mt)	Ker. (mt)	S.cok (mt)	F.wood (mt)	D.cake (mt)	Elect. (tWh)
Upto 500	0.02	0.06	0.03	0.53	0.19	0.46	0.03	0.09	0.04	0.75	0.27	0.65
500-1000	0.93	1.19	1 04	8.70	1.81	9.76	1.32	1 69	1.48	12.33	2.56	13.83
1000-1500	0.81	0.62	0.88	4.05	1.37	8.25	1.15	0.88	1.24	5.74	1 94	11.69
Over 1500	1.30	0.28	0.13	0.89	0.14	16.10	1.85	0.40	0 19	1.25	0.19	22.83
All together	**3.07**	**2.15**	**2.08**	**14.16**	**3.51**	**34.57**	**4.35**	**3.05**	**2.94**	**20.07**	**4.97**	**49.00**

Table III.5.23

Annual domestic energy demand including rural and urban households.

	Unit	Total consumption - all India[a]			Domestic requirement[b]		
		1987-88	**1988-89**	**1989-90**	**1994-95**	**1999-00**	**2004-05**
LPG	mt	1.42	1.96	2.27	12.59	17.27	23.70
Kerosene	mt	7.23	7.73	8.24			
Soft coke	mt	1.74	1.75	n.a.	9.00	14.00	20.00
Firewood	mt	n.a.	n.a.	n.a.	n.a.	n.a.	258.90
Dungcake	mt	n.a.	n.a.	n.a.	n.a.	n.a.	150.53
Electricity	tWh	187.98	187.04	208.08	40.88	82.62	145.61

n.a. denotes not available

Source: [a] LPG and kerosene from [GOI, 1991]

Soft coke from [GOI, 1990]

Electricity from [CMIE, 1989]

[b] Projected figures are as per estimates of Planning Commission [GOI,1986]

Commercial, services, and government sector

Schools, hospitals, private businesses, hotels, restaurants, Government buildings, offices and other energy consuming centres not included in agriculture, industry, transport and residential sectors comprise the commercial/services sector.

A wide variety of energy consuming end-use activities characterize this sector. These include cooking, lighting, space heating, space cooling, refrigeration and pumping. Readily available energy consumption data are not disaggregated in general, either by end-use or by type of establishment. Only published electricity consumption statistics are disaggregated as per water and sewage supply works, street lighting, commercial buildings and miscellaneous. For other fuels, it may be best to rely on information gathered through isolated sample surveys.

The sector however, is not a major energy consumer. Its energy consumption intensity in 1987/88 was 0.532 mtoe/Rs'00 billion (1980/81 prices) as compared to about 13 mtoe/Rs'00 billion for the industrial sector. In fact, the overall energy intensity as computed above, seems to have somewhat reduced from 0.601 mtoe/Rs'00 billion (1980/81 prices) in 1981/82 to 0.532 mtoe/Rs'00 billion in 1987/88. This decline in intensity perhaps reflects the increasing share of electricity consumption in the sector -- the efficiency of electricity use is more relative to that of oil products and coal/soft-coke. Over the six year period 1981/82 to 1987/88, the use of electricity in the commercial/ services/government sector grew by 12.2% per annum, while that of coal reduced by 10.7% per annum .

It may also be noted that in replacement units, the energy intensity of the sector grew from about 2.827 mtcr/ Rs'00 billion (1980/81 prices) in 1981/82 to 2.914 mtcr/Rs'00 billion in 1987/88.

Table III.6.1

Commercial/Services Sector -- Gross value added (Rs. million, 1980/81 Prices).

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
Trade, hotels & restaurants	147130	156170	165460	174170	181730	196480	208050	215670
Banking & insurance	34580	37200	43180	45930	51530	58280	65670	71430
Real estate, ownership of dwelling & business services	78110	80620	83220	85930	88730	91630	94640	97760
Public administration & defence	57940	59260	65480	67750	74460	80160	88070	96930
Other services	70410	73560	77660	80500	84570	90850	96440	102330
Total	**388170**	**407350**	**435000**	**454280**	**481020**	**517470**	**552870**	**584120**

Source:Central Statistical Organization, National Accounts Statistics, GOI, New Delhi, various issues.

Table III.6.2

Electricity consumption in commercial sector (GWh).

	1970/71	1976/77	1979/80	1982/83	1985/86	1986/87	1987/88
Commercial establishments	2572.66	4141.92	4656.58	5846.25	7761.61	7965.94	8840.81
Public lighting	492.66	594.24	711.32	835.79	1080.15	1213.76	1345.29
Public water works & sewage pumping	1016.51	1444.13	1407.76	1757.36	2129.91	2394.51	2945.44
Miscellaneous	381.67	697.74	1196.80	1640.74	1741.97	2273.42	2298.50
Total	**4463.50**	**6878.03**	**7972.76**	**10080.14**	**12713.64**	**15029.63**	**15430.04**

Sources: [1] CEA, Public Electricity Supply, All India: General Review, various issues; and [2] CMIE, Current Energy Scene in India, May 1988.

Table III.6.3

Energy consumption in Commercial/Services/Government sectors.

	Units	1981/82	1984/85	19987/88
Energy consumption				
Coal*	mt	1.089	0.837	0.618
Electricity	GWh	9040.28	11706.2	16101.89
LPG	'000 t	16.0	23.6	28.0
Kerosene*	'000 t	751.24	954.41	1157.58
Fuel oil	'000 t	395.4	484.31	258.37
Total energy cons.	**mtoe**	**2.449**	**2.849**	**3.106**
share of				
Coal	%	21.8	14.4	9.7
Electricity	%	31.2	34.7	43.8
LPG	%	0.7	0.9	0.9
Kerosene	%	30.9	33.8	37.6
Fuel oil	%	15.4	16.2	8.0
Value added	**Rs.'00 billion 1980/81 prices**	**4.073**	**4.810**	**5.841**
Intensity	**mtoe/Rs.'00 billion**	**0.601**	**0.592**	**0.532**

* Soft coke/coal and kerosene consumption are split between residential and commercial sectors in the same ratio as in 1978/79.

mtoe: million tonnes of oil equivalent.

The following factors have been used to convert fuel consumption from physical units to mtoe:

Coal/Soft-coke	1 mt	= 0.49 mtoe
Electricity	10^4 GWh	= 0.844 mtoe
LPG	1 mt	= 1.058 mtoe
Kerosene	1 mt	= 1.009 mtoe
Fuel oil	1 mt	= 0.956 mtoe

Sources:[1] Coal Controller's Organization, Coal Statistics, GOI, various issues;
[2] Bureau of Industrial costs and Prices, Report on Coal, 1983;
[3] CEA, Public Electricity Supply: All India Statistics, various issues;
[4] Department of Petroleum, Indian Petroleum and Natural Gas Statistics;
[5] CSO, National Accounts Statistics, GOI, various issues.

Table III.6.4

Energy consumption in Commercial/Services/Government sectors.

	Unit	1981/82	1984/85	1987/88
Energy consumption				
Coal*	mt	1.089	0.837	0.618
Electricity	GWh	9040.28	11706.2	16101.89
LPG	'000 t	16	23.6	28.0
Kerosene*	'000 t	751.24	954.41	1157.58
Furnace oil	'000 t	395.40	484.31	258.37
Total energy cons.	**mtcr**	**11.514**	**13.962**	**17.018**
share of				
Coal	%	14.2	8.9	5.4
Electricity	%	55.4	59.2	66.8
LPG	%	1.4	1.7	1.7
Kerosene	%	22.1	23.2	23.0
Furnace oil	%	6.9	7.0	3.1
Value added	**Rs.'00 billion (1980/81 price.)**	**4.073**	**4.810**	**5.841**
Intensity	**mtcr/Rs.'00 billion**	**2.827**	**2.903**	**2.914**

* Soft-Coke/Coal and kerosene consumption are split between residential and commercial sectors in the same ratio as in 1978/79.

mtcr: million tonnes of coal replacement.

The following factors are used to convert fuel consumption from physical units to mtcr units :

Soft-coke/coal	1 mt	= 1.5 mtcr
Electricity	10^3 GWh	= 0.706 mtcr
LPG	1 mt	= 10.184 mtcr
Kerosene	1 mt	= 3.387 mtcr
Furnace oil	1 mt	= 2 mtcr

Source:Refer to Table III.6.3

Table III.6.5

Distribution of different category of shops surveyed in Delhi.

Category of shops	Percentage of wholesale shops in urban Delhi during 1981	Number of retail shops surveyed in Delhi during 1988
Textiles	**17.8**	**36**
Autoparts	**16.3**	**33**
Food articles	**17.7**	**35**
Fruits and vegetables	7.1	14
Grocery	5.7	11
Foodgrains	4	8
Oil and ghee	0.9	2
Building materials	**11.2**	**22**
Hardware	5.5	11
Iron and steel	3.5	7
Timber and plywood	2.2	4
Consumer goods	**36.2**	**72**
Cosmetics and toiletries	1.7	3
Footwear	0.6	1
Electrical goods	3.4	7
Medicines and chemicals	3.3	7
Rubber and plastics	3.2	6
Hosiery	2.5	5
Paper, books & stationary	4.9	10
Bicycle, tyre and tubes	3.4	7
Furniture and fixtures	1.5	3
Crockery and utensils	1	2
Radio and television	1.7	3
Leather and skin	2.4	3
Others	7.3	15
Restaurants	-	**20**
Total shops	**100**	**218**

Source : TERI Data File.

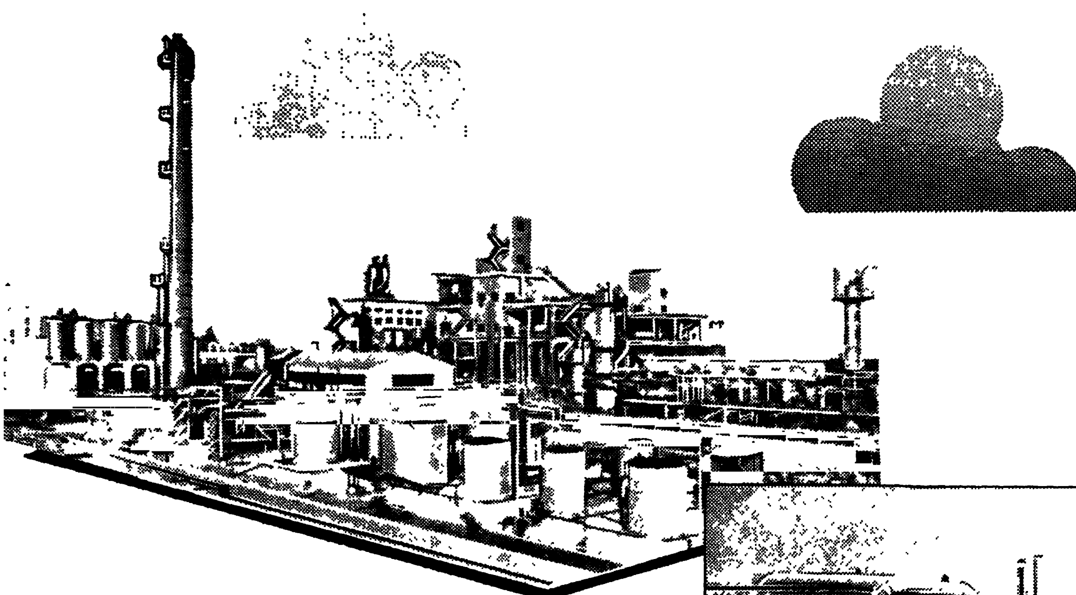
Table III.6.6

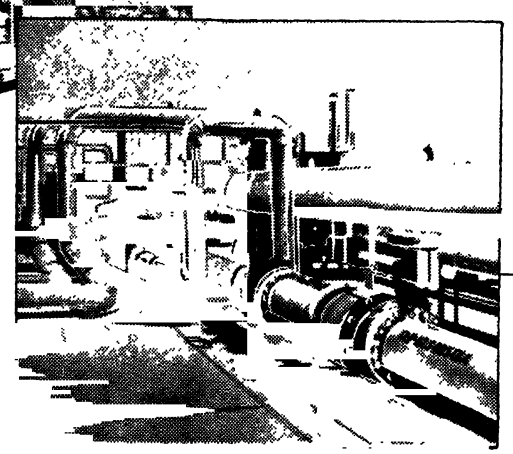
Electricity consumption for lighting per unit of plinth area in different category of shops.

Category of shops	**kWh/Sq.ft**				
	No. of Obs.	**Average**	**St.dev.**	**Min.**	**Max.**
Textiles	**37**	**11.46**	**3.71**	**4.47**	**18.87**
Autoparts	**30**	**3.19**	**1.86**	**0.46**	**6.06**
Food articles	**31**	**5.02**	**3.08**	**1.07**	**10.65**
Fruits and vegetables	11	5.69	2.93	2.28	10.65
Grocery	11	4.79	2.9	1.07	10.22
Foodgrains	7	5.03	3.64	1.31	10.35
Oil and ghee	2	2.22	0.96	1.26	3.18
Building materials	**17**	**1.95**	**0.95**	**0.46**	**4.17**
Hardware	7	2.01	0.90	0.74	3.24
Iron and steel	6	2.09	1.15	0.46	4.17
Timber and plywood	4	1.62	0.53	0.76	2.10
Consumer goods	**62**	**5.47**	**2.97**	**1.00**	**11.80**
Cosmetics and toiletries	4	7.44	3.74	1.42	11.26
Footwear	6	6.86	3.74	1.00	11.80
Electrical goods	8	3.77	1.82	2.19	8.15
Medicines and chemicals	5	4.44	1.61	2.02	6.55
Rubber and plastics	4	4.74	1.97	3.11	8.03
Hosiery	6	4.33	1.83	2.26	6.92
Paper, books & stationary	9	5.55	2.65	2.15	·9.86
Bicycle, tyre and tubes	5	6.45	2.26	3.05	8.94
Furniture and fixtures	4	6.05	2.43	4.33	9.49
Crockery and utensils	2	3.85	0.25	3.6	4.11
Radio and television	5	6.63	4.55	1.01	11.61
Leather and skin	1	2.92	-	2.92	2.92
Others	3	6.05	2.43	4.33	9.49
Restaurants	**20**	**3.28**	**1.63**	**0.91**	**6.59**

Source : TERI Data file

Energy costs and prices





Energy costs and prices

Energy pricing principles and their applications

The basic principle of pricing any energy product, is that its price should reflect its opportunity cost to the country. For most energy products, this translates into the highest price for which they may be traded either within the country, or with other countries. It is only when a particular energy product cannot be traded, or cannot be used to substitute another product which is tradeable, that the opportunity cost of the product, and therefore its price, needs to reflect its cost of production or replacement.

Although this basic principle of energy pricing is widely accepted, it is often difficult to apply because of rapidly changing conditions of supply and demand which characterize the energy products themselves, as well as of the economies in which they are used. Moreover, as energy pricing decisions may also have widespread implications for other economic sectors, the decisions need to be taken within the framework of the national development policy and social development objectives.

It is for such reasons that energy prices are administered in most countries including India; and do not reflect the opportunity cost to the country. In fact, some energy products have usually been subsidized to such an extent that the supply industry has not been able to generate adequate resources internally to expand rapidly enough to keep pace with rising demand. Shortages of coal and power supplies have thus emerged in India over the past decade.

Against this background, a knowledge of opportunity costs of supplying any energy product is essential to an energy planner. Only with such information, the energy prices may gradually be shifted towards reflecting the economic supply costs. With these prices, it is hoped that consumers will receive appropriate signals to align their energy consumption pattern (over a reasonable period of time) with the indigenous energy resource endowments and international energy market conditions. However, such economic cost data are not usually documented; at most, financial cost data are available.

Furthermore, due to the high degree of substitutability, it is important to take an integrated approach and view the problem of energy pricing across products. The use of soft-coke, kerosene and LPG for cooking, coal and fuel oil in industrial boilers, and diesel oil and electricity for rail traction are examples of the extent to which energy products may substitute each other if the consumer invests in appropriate capital stock.

Coal pricing

The Indian coal industry has incurred heavy losses during the past decade. Coal prices have been set below production costs (although the average cost of production and the sale price differential of coal at the pithead is narrowing), and also far below the price of fuel oil – its major substitute for application in industrial boilers. Some justification may, however, be advanced for keeping coal prices below fuel oil prices on a thermal equivalent basis: (i) strategic considerations, to reduce dependence on an imported fuel; and (ii) social considerations, arising from the fact that the price differential between the two fuels is so high that nullifying it would create strong inflationary pressures with immense social costs. On the other hand, pricing coal below production costs is difficult to justify.

In fact, there seem to be certain flaws in the methodology adopted for fixing coal prices. Coal production costs of all mines are averaged, which allows uneconomic mines to co-exist with economic production centres. As costs are averaged, losses in individual mines are ignored, and proper identification of mines for priority investments is not possible. Likewise, as all costs incurred by each mine are taken into account while estimating average costs, due attention is not paid to the inefficiencies inherent in the operations of certain mines. Inefficient mining practices therefore, continue.

There is a glaring discrepency observed in the present price structure of non-coking coals, whereby some of the inferior grade coals are priced higher per unit of heat value as compared to superior grades of coal. There is no systematic or logical principle adopted for inter-grade price differentials. Also, a uniform price is charged for coal within each grade (with widely varying heat value). this is based on the lowest UHV in the specified range of each grade. As a result, there is no incentive for the coal producers to supply coal with higher heat value covered in that grade. Moreover, the entire pricing procedure focuses only on pithead costs, regardless of the cost of coal delivered to the consumer. Transportation charges, royalty and cesses, which are included in the consumer price, are not adequately considered. Consequently, the grade-wise price differential (at the pithead) becomes meaningless at the consumers' end due also to the high cost of transportation. Consumers therefore prefer to use high grades of coal (which are scarce) and there is little incentive to switch to inferior grades.

Table IV.2.1
Average pithead price of coal (Rs/tonne).

1960	20.75
1965	23.78
1970	35.68
1972	36.41
1974	51.46
1976	70.14
1978	70.37
1980	118.95
1982	157.26
1984	204.87
1986	230.11
1987	230.48
1988	228.75
1989	273.00

Source: Centre For Monitoring Indian Economy, Basic Statistics Relating to the Indian Economy, Vol.1: All India, August, 1991.

Table IV.2.2

Pithead price of Non-coking coal.

Grade	Useful heat value (kCal/kg)	Price (Rs/tonne)	Price per unit of slack coal** Rs/10⁶ kCal
Long flame[b] coal produced in all states*			
Grade A	> = 6200	427	68.87
Grade B	5600 - 6200	392	70.00-63.22
Grade C	4940 - 5600	346	70.04-61.78
Grade D	4200 - 4940	280	66.67-56.68
Coal produced in all states *			
Grade A	> = 6200	402	64.84
Grade B	5600-6200	367	65.55-59.19
Grade C	4940-5600	321	65.00-57.32
Grade D	4200-4940	255	60.71-51.62
Grade E	3360-4200	203	60.41-48.33
Grade F	2400-3360	163	67.91-48.51
Grade G	1300-2400	117	90.00-48.75
Coal produced in Singareni coalfields			
Grade C	4940-5600	363	73.48-64.82
Grade D	4200-4900	320	76.19-64.78
Grade E	3360-4200	271	80.65-64.52
Grade F	2400-3360	205	85.54-61.01
Grade G	1300-2400	160	123.08-66.67
Coal produced in Assam, Meghalaya, Nagaland and Arunanchal Pradesh (ash content not exceeding 25%)	---	460 @	83.64

* Excludes Assam, Meghalaya, Nagaland and Arunachal Pradesh and Singareni Collieries.

** When the Useful Heat Value(UHV) of non-coking coal exceeds 6400 kCal/kg,the price payable for Grade A shall be increased at the rate of Rs.1 for every 100 kCal by which the actual UHV exceeds 6400 kCal/kg. The pit-head prices are exclusive of royalty, cesses, taxes and levy, (if any, levied by the Govt., local authorities or other bodies) duties of excise and sales tax. The prices of steam coal and rubble are higher by Rs.7/tonne for each grade of non-coking coal; the prices of run-of-mine coal are lower by Rs.3/tonne for each grade.

@ In case of coal produced in the States of Assam, Meghalaya, Nagaland and Arunachal Pradesh, the price payable shall be increased at the rate of Rs.11/tonne, per percent of ash by which the ash content falls below 22%.Similarly, when ash content exceeds 25%, the price shall be reduced at the rate of Rs.11 per tonne per percent of ash by which the ash content exceeds 25%.

[b] long flame coals may be defined by the parameters laid down in Indian standard no. IS:770-1964-"general Classification of Coals (Revised)". The relevant part is given below:

Group	Volatile matter % (unit coal basis)	Range of gross calorific valuein kCal/kg (unitcoal basis)	Range of dried moisture present 60% RH at 40°C
B4	over 32	8060 to 8440	3 to 7
B5	over 32	7500 to 8060	7 to 14

Source: Ministry of Energy, Department of Coal, Notification, New Delhi, 30 December, 1988, The Gazette of India: Extraordinary, Part II-Section 3(ii).

Table IV.2.3

Pithead price of coking coal.

Grade*	**Ash Content**	**Sale price of slack coal** (Rs/tonne)**
S-I	= < 15%	654
S-II	= < 18%	546
W-I	= < 21%	473
W-II	= < 24%	393
W-III	= < 28%	303
W-IV	= < 35%	283
S/C-I	= < 19%	473
S/C-II	= < 24%	393

* S-I and S-II are steel grade prime coking coals. W-I, W-II, W-III and W-IV are medium coking coals that need to be prepared in washeries. S/C-I and S/C-II are semi or weakly coking coals. When the ash plus moisture content of semi-coking Grade I (S/C I) coals is less than 17%, the prices payable for S/C I shall be increased at the rate of Rs.5 for every 1% decrease in ash plus moisture content below 17%. The pit-head prices are exclusive of royalty, cesses, taxes and levy, if any, levied by Government, local authorities or other bodies, duties of excise and sales tax.

** Price of steam coal and rubble is higher by Rs.7/tonne for all grades of coking coal; and price of run-of-mine coal is lower by Rs.3/tonne for all grades.

Source: Ministry of Energy, Department of Coal, Notification, New Delhi, 30 December, 1988, The Gazette of India: Extraordinary, Part II-Section 3(ii).

Table IV.2.4

Cost parameters of opencast coal mining*

	Capital cost (Rs/tpa)	**Annual operating costs** (Rs/t)**
a. Weighted average	581	155
b. Max. capital cost	872	NA
c. Min. capital cost	204	NA
d. Max. operating cost	NA	222
e. Min. operating cost	NA	64

* Expressed in 1985 Prices.

** Assuming 100% capacity utilization.

a. Weighted average of 12 projects, using various technologies for opencast mining. All are however, mechanized.

b. For a mine of 12 mtpa capacity, 10.88 tonne OMS, 4.5 stripping

c. For a mine of 10 mtpa capacity, 9.58 tonne OMS, 1.0 stripping ratio, and using 10 cu.m. rope shovels and 120 tonnes rear dumpers for overburden removal.

d. For a mine of 3 mtpa capacity, 8.71 tonne OMS, 5.13 stripping ratio and using draglines along with 10 cu.m. rope shovels and 120 tonne rear dumpers for overburden removal.

Source: Planning Commission, Draft Report of The Expert Group on Mine capacity ranges from 1 mtpa to 14 mtpa. OMS ranges from 3.29 tonnes to 13.25 tonnes, with a weighted average of 9.96 tonnes. ratio, and using 10 cu.m. rope shovels and 120 tonne rear dumpers for overburden removal. Technology Options for the Coal Industry, May 1986.

Table IV.2.5
Cost parameters of underground coal mining *.

	Capital cost (Rs/tpa)	Annual operating costs** (Rs/t)
a. Weighted average	729	188
b. Max. capital cost	830	NA
c. Min. capital cost	262	NA
d. Max. operating cost	NA	241
e. Min. operating cost	NA	92

* Expressed in 1985 prices.
** Assuming 100% capacity utilization.
a. Weighted average of 12 projects using various technologies for underground mining. Mine capacity ranges from 0.24 to 3.5 mtpa. OMS ranges from 0.39 tonnes to 4.26 tonnes with a weighted average of 2.75 tonnes.
b. For a mine of 2 mtpa capacity, 3.9 tonnes OMS and using the mechanized Longwall method of mining.
c. For a mine of 0.42 mtpa capacity, 1.2 tonnes OMS and using the mechanized Bord and Pillar Method.
d. For a mine of 0.3 mtpa capacity, 0.39 tonnes OMS and using the manual Bord and Pillar Method.
e. For a mine of 0.24 mtpa capacity, 2.4 tonnes OMS and using the Blasting Gallery method.
Source: Planning Commission, Draft Report of The Expert Group on Technology Options for the Coal Industry, May 1986.

Petroleum pricing

Hydrocarbon pricing is very complex and prices are fixed by the Government from time to time, for various stages of the supply industry. The issue of pricing crude oil is complex because in addition to producing indigenous crudes from onshore and offshore fields, India also imports crude oils. Therefore, the crude oil prices paid to the petroleum exploration and development organizations are decided not only on the basis of costs incurred in the exploration and development, but also on the basis of international crude market conditions, and on the financial requirements for expanding exploration and production activities. The second stage of deciding prices paid by the refiners to procure indigenous and/or imported crudes, relates mainly to how the "economic rent" available

from the use of an exhaustible resource, is to be shared between the producing and refining organizations. The third stage of fixing retention prices for refineries aims not only to provide an incentive for efficient refining operations, but also to rationalize the refinery output mix in line with the demand mix while ensuring the financial viability of refining companies. Likewise, retention prices for distributing and marketing agencies are fixed on the basis of certain efficiency norms of operations, including the use of common pipeline facilities.

Finally, consumer prices are fixed on the basis of certain social considerations. These prices are administered through a series of pool accounts.

The weighted average of distribution costs for each product is incorporated in the price build-up, so that the price of a particular product is uniform all over the country. Any differences in consumer prices from one state to another, are due largely to differences in tax rates levied by the respective State Governments.

Although the weighted average of consumer prices has been maintained at parity or higher than border prices, cross-subsidization of products has posed certain problems. In addition, to reduce the adulteration of high speed diesel oils by kerosene, the Government has had little choice but to keep the price differentials between the two products low. However, this has resulted in a high price differential between petrol and diesel -- which has prompted several automobile owners to retrofit their vehicles with inefficient diesel engines. This pricing policy has therefore resulted in further increasing the demand for kerosene and high speed diesel oil, both of which are middle distillates and are imported at the margin.

Table IV.3.1

Prices of indigenous onshore and offshore crude oils* (Rs/tonne).

	With effect from					
	Dec. 16, 1977	July 11, 1981	Feb. 15, 1983	April 1, 1984	March, 1987	Feb 1, 1989
Onshore crude oils						
Base price	203.41	1021	1021	1021	1021	1021
Cess	60	100	300	300	600	900
Royalty	42	61	61	192	192	192
Total	**305.41**	**1182**	**1382**	**1513**	**1813**	**2113**
Offshore crude oils						
Base price	331.65	1021	1021	1021	1021	1021
Cess	60	300	300	300	600	900
Royalty	42	61	192	192	192	192
Total	**433.65**	**1382**	**1513**	**1513**	**1813**	**2113**

* The prices presented here are for crude oils of 34 API gravity. They are subject to an escalation of Rs.0.16/ API, upto a maximum of 45 API. No downward limit on the API gravity for a de-escalation in prices is specified. The prices are also inclusive of sales tax, which is the liability of the producer.

Source: Department of Petroleum, Indian Petroleum and Natural Gas Statistics, GOI, New Delhi, 1989-90, 1990-91.

Table IV.3.2

Retail selling prices of selected petroleum products (in Bombay).

Prices as on	Mogas/Petrol* (Rs./litre)	HSD (Rs./litre)	Kerosene (Rs./litre)	LPG ** (Rs./cylinder)
Jan 1,1971	1.16	0.79	0.54	NA
Jan 1,1972	1.42	0.83	0.57	NA
Jan 1,1973	1.43	0.83	0.61	NA
Jan 1,1974	2.81	0.81	0.82	20.01
Jan 1,1975	3.26	1.06	1.04	22.10
Jan 1,1976	3.36	1.28	1.21	26.75
Jan 1,1977	3.39	1.27	1.21	26.75
Jan 1,1978	3.38	1.27	1.18	26.75
Apr 1,1979	4.04	1.39	1.29	26.94
Aug 17,1979	4.43	1.58	1.46	33.96
Nov 11,1979	-	1.50	1.39	33.96
Jun 8,1980	5.15	2.21	1.39	33.96
Jan 13,1981	5.56	2.61	1.49	38.94
Jul 11,1981	6.15	2.96	1.60	43.52
Apr 1,1982	6.15	2.96	1.66	43.52
Feb 15,1983	6.21	3.21	1.70	43.14
Apr 1,1983	6.21	3.21	1.80	43.14
Apr 1,1984	6.32	3.21	1.81	43.14
Jun 1,1984	6.41	3.27	1.85	44.11
Apr 1,1985	7.34	3.45	2.03	49.95
Apr 1,1986	7.79	3.57	2.17	56.15
Apr 1,1987	7.79	3.63	2.17	56.15
Apr 1,1988	9.14	3.63	2.17	56.15
Apr 1,1989	9.14	3.63	2.17	56.15
Apr 1,1990	10.76	4.30	2.17	56.15
Apr 1,1991	13.72	5.62	2.66	56.15

* Price for Mogas 83 until April 1, 1983; Price for Mogas 87 thereafter.

** Price for a 15 kg cylinder until Jan 1, 1975; Price for a 14.2 kg cylinder thereafter.

Source: Department of Petroleum, Indian Petroleum and Natural Gas Statistics, GOI, New Delhi, 1989-90, 1990-91.

Electricity pricing

The basis for setting electricity prices can be very different from coal or petroleum prices, even if only because electric power cannot be usually stored; which means that the cost of meeting power requirements vary with the time of day. Therefore, it is clear that the power tariff during peaking hours must be higher than during off-peak hours -- at least for major electricity consumers. This practice however, has not been adopted in general in India so far. One of the reasons is that appropriate meters are too expensive or not available -- which can record the electricity consumption during peaking hours separately.

In fact, the average electricity tariffs in India are usually below the costs of power generation and supply. As a result, the electric utilities in India have generally found it difficult to expand their generating capacity (to keep pace with rising demand) and to modernize their facilities. The problem is compounded further when due to lack of adequate financial resources, project implementation slows down, thus leading to substantial cost over-runs, and a further rise in supply costs. At the same time, strengthening and expanding the transmission grid is not given adequate consideration, as investment allocated for transmission projects gets reallocated for generation schemes. Moreover, as the rural electrification programme has continued to expand, an increasing share of elctricity is consumed in the agriculture sector -- which has the lowest tariff although the costs of power supply to it are probably the highest. Apart from the overall tariff being much below the average costs in the agriculture sector, it is framed in the form of a "flat rate" tariff. The consumers in this category are charged a flat rate based on their connected load (per HP of pumpset) irrespective of the hours of use. This goes against the basic economic principles, as the marginal cost of usage of the pumpset is zero in such a case. Also, flat rate tariffs encourage misuse and wastage of electricity.

An appropriate tariff structure can play a significant role in demand management and electricity conservation.

Table IV.4.1
Electricity tariffs (All India Average)

	(paise/kWh)
1970/71	12.44
1972/73	14.15
1974/75	18.39
1976/77	23.79
1978/79	28.99
1979/80	31.28
1980/81	33.23
1981/82	38.76
1982/83	43.45
1983/84	51.55
1986/87	61.09

Source: Central Electicity Authority.

Table IV.4.2

Average cost of generation & supply and average rate of realisation in 1987-88.

	Average cost of generation and supply	Average rate of realisation				Overall average realisation
		Domestic	*Agriculture*	*LT-industry*	*HT-industry*	
Andhra Pradesh	65.40	52.30	4.50	111.40	94.90	60.8
Bihar[@]	149.20	57.34	9.40	171.20	132.50	93.5
Gujarat	102.50	67.78	24.80	113.80	116.20	82.9
Haryana	81.20	56.00	30.00	100.00	109.00	59.8
Himachal Pradesh	91.00	43.50	20.00	71.60	71.60	56.6
Karnataka	74.60	63.00	11.60	103.30	90.10	72.6
Kerala	66.60	48.70	22.00	60.00	57.90	56.3
Madhya Pradesh	83.60	27.58	23.20	87.00	94.30	73.5
Maharashtra	87.90	46.97	8.65	76.00	118.00	80.0
Orissa	66.20	44.00	22.10	53.30	65.90	65.6
Punjab	97.90	67.87	8.40	68.80	61.30	44.0
Rajasthan	98.50	58.22	29.50	83.70	91.80	81.1
Tamil Nadu	89.60	52.10	11.20	98.00	85.00	63.7
Uttar Pradesh	99.80	65.50	22.70	103.00	114.90	68.0
West Bengal	123.50	58.50	25.60	77.80	130.10	95.2
Assam	257.00	60.00	50.00	62.00	87.00	91.9
Meghalaya	99.90	44.40	21.00	55.00	55.00	50.0

[@] Relates to 1986-87

Source: Centre for Monitoring Indian Economy (CMIE), Current Energy Scene in India, July 1989, Bombay.

Table IV.4.3

Average rates of electricity supply - as on April 1, 1989.

Consumer category	Minimum tariff		Maximum tariff	
	State/City	*Average rev.**	*State/City*	*Average rev.**
Domestic lights and fans 30 kWh/month	Delhi	29	Ahmedabad	79.59
Commercial lights and fans 200 kWh/month	Arunachal Pradesh	42	Bombay (suburban)	190.0
Agriculture 5 HP 10% LF 272 kWh/month	Andhra Pradesh	9.5	Ahmedabad	69.01
Small industries 5 HP 10% LF 272 kWh/month	Tripura & Lakshadweep	40.0	Bombay (BEST)	155
Medium industries 50 kW 30% LF 10950 kWh/month	Lakshadweep	32.74	Bombay (BEST)	155.54
Large industries 1000 kW 50% LF 365000 kWh/month	Sikkim	38.88	Bombay (BEST)	125.66

* Includes Fuel Cost Adjustment Charge.

Source: Central Electricity Authority, Average Electric Rates and Duties in India, May 1989.

Firewood and charcoal pricing

Firewood is an important fuel for India's poor -- both in rural and urban areas. Although much work has been done on fuelwood use in rural areas, not much attention has been paid to urban use of fuelwood. Available information on urban use of fuelwood is not reliable -- estimates vary from 16 MMT to 29 MMT for the 1979 to 1981 period. However, one thing is clear -- that a large share of this firewood was purchased by the poor urban consumers, like any other commodity. Available information also indicates that fuelwood prices have risen substantially during the 1980s; perhaps reflecting the need to transport it over increasingly long distances (in diesel fuelled trucks).

A certain (unknown) fraction of firewood that is brought to the cities is not sold directly, to consumers, but converted to charcoal in rather inefficient kilns. The price of charcoal also has increased significantly in recent years.

Table IV.5.1

Retail Prices of Firewood (Rs/40 kg).

	1980	1981	1982	1983	1984	1985	1986	1987
Bangalore	13.60	15.32	18.00	23.06	23.74	25.18	27.86	26.36
Calcutta	19.17	22.93	26.62	26.54	27.38	31.52	39.09	41.43
Delhi	19.13	24.38	28.59	31.88	38.55	41.75	48.00	49.03
Hyderabad	12.37	16.06	19.66	23.23	26.00	26.33	27.88	25.62
Madras	19.25	20.66	21.36	23.00	26.29	28.40	28.90	28.80

Note : The above are the prevailing prices in the month of April of each year.

Source: Centre for Monitoring Indian Economy (CMIE), Current Energy Scene in India, July 1989, Bombay.

Table IV.5.2

Retail prices of charcoal (Rs/40 kg).

	1980	1981	1982	1983	1984	1985	1986	1987
Ahmedabad	44.19	45.94	49.13	72.00	80.00	92.12	86.42	110.00
Bangalore	29.88	30.00	37.81	38.00	45.00	49.87	50.25	63.00
Bombay	39.33	40.00	44.17	62.50	76.75	80.34	80.08	94.79
Calcutta	39.71	39.75	43.46	56.63	63.00	64.75	73.75	100.00
Delhi	45.10	48.80	56.40	83.60	89.60	98.80	120.00	120.00
Hyderabad	36.00	39.22	41.34	60.44	70.83	78.94	76.66	78.90
Kanpur	42.19	46.25	56.64	87.63	100.00	100.00	104.37	120.00
Madras	48.98	49.20	57.74	60.64	84.24	83.52	90.99	92.06

Note: The above are the prices prevailing in the month of April of each year.

Source: Centre for Monitoring Indian Economy (CMIE), Current Energy Scene in India, July 1989, Bombay.

Technology development

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Technology development

Introduction

The supply and demand scenario for the so-called "conventional" energy forms is presented in the preceding sections. However, with technological development, it becomes possible to: (i) harness certain renewable energy sources, such as solar and wind, as also hydroelectric potential from low heads; and (ii) improve the utilization efficiency of certain fuels that are already used, such as firewood, crop residues and animal wastes.

The Government's renewable energy technologies (RETs) programme is coordinated by the Department of Non-conventional Energy Sources (DNES). While large scale dissemination has already begun for some relatively mature technologies such as improved chulhas, biogas plants, solar cookers and solar water heating systems, other technologies are still at the research, development, demonstration or pilot field testing stages. However, it is essential that all renewable energy technologies and devices used in rural and urban areas must hold promise of providing net benefits to society--albeit in the long run. Present day cost competitiveness vis-a-vis conventional technologies need not be the sole criterion, particularly if recent trends in technological innovation and cost reduction are encouraging.

That financial incentives are required for promoting RETs is recognized by the Government. In India, such incentives have largely been in the form of a direct subsidy (from the Central Government) or in some instances, soft loans and sales tax exemptions (as offered by the Governments of certain states and union territories). Such financial incentives have been confined largely to those who install and use biogas plants, improved chulhas, solar cookers and other solar thermal devices. However, the progress of India's RET programme has been hampered substantially by the fact that most consumers, who have not had to invest much (certain categories have received 100% or nearly 100% direct subsidy) in getting the RET devices installed, feel little responsibility towards ensuring that their devices work. Besides, the "after sales service" network has not been developed. Furthermore, the ongoing subsidy programme of the central Government has been a drain on its financial resources. That little technical improvements have been made for certain products (particularly, low grade solar thermal devices) since the subsidy programme was initiated in the early eighties is evident from the fact that demand for them reduced significantly as soon as the subsidy levels were reduced. It is clear therefore, that in order to sustain the renewable energy programme,

there will have to be considerable inputs in terms of R&D. In fact, in order to ensure that the RET demonstration and dissemination programmes are properly designed and conducted, considerable inputs from engineers, sociologists, economists and skilled labour/artisans etc. will also need to be mobilized.

Solar thermal technologies

The vast solar energy potential is being tapped through both the thermal and photovoltaic routes. On the solar thermal side, considerable progress has been made in solar cookers and solar water hearing systems. Considerable work is in progress also on other fronts, as detailed below.

Research, development and demonstration programme

The basic thrust is two-fold:

(i) to develop new, efficient, durable and low cost materials for applications in technologies which are already near full commercialization; and

(ii) to develop equipments/devices and processes to convert solar energy into heat and further on to mechanical and electrical energy, as well as to develop heat storage systems.

New materials. Development of UV resistant plastic materials for glazing, cheaper selective coatings and plastics for absorbers and sealants is being done on a priority basis. Extensive studies carried out on EPDM rubber have shown its suitability for solar thermal applications under Indian conditions. "Tedlar", another plastic material has been found to be suitable as glazing material for solar collectors. Its monomer has already been developed and tested for various optical properties and tensile strength etc. and efforts are now being made to polymerise the monomer. A pilot plant is being set up at the DNES' Solar Energy Centre (SEC) for coating the collector receiver tubes of parabolic trough collectors with Black Cobalt selective coating using spray pyrolysis method developed through a sponsored R&D project at the Indian Institute of Technology, Delhi.

Solar refrigeration. The DNES has sponsored R&D projects to develop solar refrigeration and cold storage plants for the storage of life saving drugs and vaccine and other perishable dairy and agricultural produce in remote, un-electrified areas. A solar refrigerator capable of producing one kilogram of ice per day using water zeolite system has been developed. This has been achieved jointly by SEC and Sardar Patel Renewable Energy Research Institute, Vallabh Vidyanagar. The technology is now being improved and up-scaled.

Thermal pump. The main purpose is to increase water availability in areas where the groundwater table is low. With German collaboration, a 1 kW (hydraulic) solar thermal pump has been developed, which can draw up to 60 cubic metres of water from a depth of up to 50 metres on a clear sunny day. However, its techno-economic viability is still

to be established.

Solar pond. Provided land is available, the solar pond technology is recognized as being probably the most attractive option for meeting large process heat requirements. With this in view, Asia's largest solar pond (of 6000 sq. metres) area has been successfully constructed and stabilized at Bhuj in Gujarat. It is expected that this pond will provide about 90,000 litres of hot water at 80 degrees celsius to the Bhuj dairy for meeting various process heat requirements. This pond will also be used for conducting experiments on desalination, drying and other similar applications.

Energy storage. In view of the intermittent and diffused nature of solar energy, development of materials and methods for energy storage is essential to make systems based on solar thermal energy more reliable and cost effective. Punjab University, Chandigarh, has successfully developed energy storage materials for -20°C to 150°C temperature range. Efforts are new being made to design suitable heat exchangers which may use these materials for energy storage in conjunction with low grade solar thermal devices for a variety of applications.

Solar passive buildings. The increasing requirement of conventional energy for keeping the living/working space comfortable (and the growing concerns relating to the concomitant environmental implications) have prompted interest in pursuing solar passive features in building design and architecture. Although a small beginning has been made, considerable effort would be required to propagate this on a large scale. Besides setting standards for building design, architects and builders will need to be trained, and users to be made more aware.

Power generation. Solar energy can also be converted into electricity through the solar thermal route. Two experimental solar thermal power plants of capacity of 20 KW and 50 KW have been installed in the country at Salojippally near Hyderabad and SEC at Gual Pahari, respectively. A proposal for setting up a 30 MW Solar thermal power plant is being appraised for its techno-economic viability.

Extensive programme

After the successful demonstration of indigenously developed low grade solar thermal technologies in the early eighties, a cost sharing scheme for the utilisation of solar cookers, water heaters, dryers, air heaters, wood seasoning kilns and water desalination systems was started in 1984. In order to encourage the users to make use of these new systems, a cost sharing scheme was introduced. Initially, the share of the Government was large, but has been reduced successively during the years. The percentage of Government share during financial year ending on 31 March 1991 is shown in Table V.2.1.

Under this programme, 3430 industrial/commercial and 5484 domestic solar waterheater systems, 51 solar air heaters/crop dryers, 45 solar timber kilns and 8585 solar stills were installed in the country by December 1990. A collector area of 172,000 sq. metres installed for these applications can generate about 115 GWh of thermal energy per annum. Over 177,000 solar cookers have also been sold.

Table V.2.1
Cost sharing scheme for installation of low grade solar thermal systems and devices (1990-91).

Category of users	**% of Govt. sharing**
Private sector	30%
Govt. public sector enterprises	30%
State Govt. buildings, cooperative Societies, central Govt. buildings, Govt. institutions, IITs, Universities, Schools, Anganwadies, Charitable and religious bodies	50%
Domestic Solar Water Heaters*	50%
Solar Cookers**	33 1/3%
Community Solar Cookers***	33 1/3%

* Subject to a maximum of Rs.3,000/- per Solar Water Heating system unit.
** Subject to a maximum of Rs.150/-per solar cooker.
*** Subject to maximum of Rs.1,050/-per community solar cooker.

Solar photovoltaics

Solar photovoltaics (SPV) technology is one of the ways of generating electricity directly from sunlight. Considerable efforts have been made during the eighties to develop a research base in SPV technology as well as indigenous production capability. However, rapid strides in SPV technology overseas have far outpaced the progress made in India, and today, the quality and efficiency of SPV cells produced indigenously do not match international standards. The costs are also relatively higher.

As a result, the DNES' SPV demonstration and utilization programme has fallen behind the targets set initially in certain areas. It is now becoming increasingly evident that small/low-power applications would be most attractive, and particularly in remote areas. For instance, the Indian railways have been using SPV for a variety of

applications. About 250 railway station/halts have been using SPV systems for distance signalling, panel interlocking systems, station lighting, microwave repeaters etc.

As far as DNES' participation in the National Literacy Mission (by providing SPV power packs in adult education centres) and the National Drinking Water Mission (by providing SPV powered deep well pumping systems) is concerned, the economic viability needs to be reworked. For in rural areas which are already electrified (i.e. more often than not, an 11 kV subtransmission line has already been laid), the installation of high cost SPV systems make little economic sense.

Wind energy programme

The wind energy programme in India was initiated in 1985 and by 31.10.91 more than 102 million kWh of electricity had been feed into the grid. 38 Mw wind forms have been commissioned, out of the 46 MW taken up so far and further 10 MW of wind form projects are under consideration for the year 1992-93.

A Wind Energy Data Handbook was published in 1983, based on our analysis of information and data on wind, available from the vast network of meterological observatories. In 1985, an extensive wind resource assessment programme was taken up comprising of wind monitoring, wind mapping and complex terrain projects. State wise wind survey projects are given in tables 1.0 & 2.0. The first volume of Wind Energy Resource survey for India was published in 1990, which covers three year's wind data from 21 wind monitoring stations. The second volume will be published in 1992 with three year's data from 36 stations, as well as five year's data from 13 stations, and four year's data from 9 stations.

The experience with the windpumps has not been encouraging and now better proven models for deep well pumping are being installed in 1992-93 about 80 such units are expected to be installed. A small capacity (about 40 miles) of stand alone systems to a maximum of 5 Kw unit capacity will be installed as demonstration projects in 1992-93.

Table V.4.1

Wind resource assessment projects.

State	Wind monitoring stations	Wind mapping stations
Gujarat	20	80
Tamil Nadu	20	30
Rajasthan	9	30
Karnataka	9	30
Maharashtra	9	30
Andhra Pradesh	9	50
Kerala	9	30
Orissa	9	41
Madhya Pradesh	5	30
Lakshadweep	5	-
Andaman & Nicobar	5	-
Himachal Pradesh	-	30
Uttar Pradesh	-	30
Meghalaya	-	10
Tripura	-	10
West Bengal	-	30
Assam	-	30
Bihar	-	30
Arunachal Pradesh	-	10
Haryana	-	10
Goa	-	
Total	**109**	**541**

Source: Ajit K Gupta, SESI Convention 1991.

Table V.4.2

Wind monitoring stations with mean annual windspeeds greater than 18 kmph.

S. No	Station	Mean annual wind speed	S. No	Station	Mean annual wind speed	S. No	Station	Mean annual wind speed
I	**Tamil Nadu**	(kmph)	III	**Gujarat**	(kmph)	VII	**Kerala**	(kmph)
1	Sultanpet	19.1	1	Harshad	20.8	1	Kanjikode	23.5
2	Poolavadi	20.2	2	Okha	20.2	2	Kottathara	20.9
3	Andipatti	19.1	3	Mundra	20.1	3	Kotamala	18.6
4	Kayathar	20.6	4	Surajbari	18.3	4	Ponmudi	20.0
5	Kuppandal	26.1	5	Okha Madhi	18.7	VIII	**Andhra Pradesh**	
6	Sembagaramanpudur	21.8	6	Navi Bander	20.7	1	Tirumala	20.3
7	Puliyankulam	19.1	7	Dhank	24 5	2	Payalakuntla	20.8
8	Alagiyapandiyapuram	22.2	8	Kumma	18.6	3	Narasimhakonda	21.0
9	Talayathu	20.2	IV	**Maharashtra**		4	Kukulakonda	25.5
10	Ayikudy	22.6	1	Vijayadurg	19.3	5	NPR Dam	20.7
11	Kattadimalai	25.1	2	Panchgani	18.3	6	Ramagiri	20.6
12	Rameswaram	24.1	3	Chalkewadi	19.3	7	Bhimunipatnam	18.7
13	Ketukadai	22.7	V	**Rajasthan**				
14	Metukadai	18.4	1	Khodal	18.0			
15	Meenakshipuram	18.7	2	Jaisalmer	18.1			
16	Arasampalayam	21.4	VI	**Karnataka**				
17	Edayarapalayam	23.4	1	Gokak Hilla	20.3			
II	**Lakshadweep**		2	Malgatti	20.2			
1	Kadmath	18.1	3	Hanamsagar	21.1			
2	Agatti	18.6	4	Jogimatti	32.5			
3	Kavaratti	18 3	5	Bommanahatti	19.1			
			6	Hanumanhatti	21.1			

Source: A. K Gupta; SESI Convention 1991

Table V.4.3

Status of installation of wind power projects.

State	Total Installed		Demonstration wind farm projects		Private sector projects	Individual grid connected machine	
	Completed	U/IMP.	Completed	U/IMP.	Completed	Completed	U/IMP.
Tamil Nadu	19.24	3.42	13.85	3.00	5.00	0.39	0.42
Gujarat	14.74	2.25	14.50	2.05	-	0.24	0.20
Maharashtra	1.19	1.50	1.10	1.50	-	0.09	-
Orissa	1.19	-	1.10	-	-	0.09	-
Madhya Pradesh	.64	-	0.50	-	-	0.14	-
Andhra Pradesh	.55	-	0.55	-	-	-	-
Karnataka	.55	-	0.55	-	-	-	-
Goa	.11	-	-	-	-	0.11	-
Kerala	.10	-	-	-	-	0.10	-
Total	**38.31**	**7.17**	**32.15**	**6.55**	**5.00**	**1.16**	**0.62**

U/IMP: Under implementation.

Source: A.K. Gupta, SESI Convention, 1991.

Table V.4.4

Statewise break-up of windfarms.

State	Locations	Capacity (MW)	Com. output* (million Kwh)
Tamil Nadu	Tuticorin, Kayattur, Mupperulal	13.85 (3.0 UI)	59.41
Gujarat	Okha, Claha-Madlu Lamba, Mardvi & Tena	14.50 (2.05 UI)	36.56
Maharashtra	Degogad	1.10 (1.50 UI)	3.30
Andhra	Tirumala	0.55	-1.05
Orissa	Puri	1.10	1.18
Karnataka	Talcauvery	0.55	-
Madhya Pradesh	Kheda	0.50	0.94
	Total	32.15	102.44

* ending Oct. 1991.

Table V.4.5
Size wise break-up.

WEG size (kW)	**Installed**	**Under implementation**
55	94	14
90/100/110	32	-
150	12	-
200	107	2
225/250	2	20
300	-	5
Total	**247**	**40**

Table V.4.6
Year-wise break-up.

Year of installation	**Capacity MLU**
1985-86	2.20
1986-87	1.43
1987-88	0.77
1988-89	1.90
1989-90	25.10
1990-91	0.20
1991-92	0.55

Table V.4.7

Project wise break-up of wind farm projects in India.

S. No	State	Location	Implementing agency	Installed capacity (MW)	WEG details unit No	WEG details unit Capacity	WEG details unit Regulation	Date of installation	Cumulative output (lakh kWh) (up to 31.10.91)
1	Andhra Pradesh	Tirumala	NEDCAP	0.55	5	110	S.R	Jun 89	10.53
2	Gujarat	Mandvi	GWFL	1.1	2	110	S.R	16	97.13
					14	55	S.R	Jan 86	
					3	22.5	S.R		
				0.5	2	250	S.R	29 Aug 89	12.15
		Okha	GEB	0.55	10	55	S.R	08 Mar 86	39.38
		Okha Madhi	GEDA	1.80	12	150	S.R	25 July 89	37.43
		Lamba	GEDA	10.00	50	200	P.C	30 Apr 90	178.94
		Tuna	GEDA	0.55	10	55	S.R	Nov 91	-
3	Maharashtra	Deogad - I	MSEB	0.55	10	55	S.R	23 May 86	23.70
		Deogad - II	MSEB	0.55	10	55	S.R	Dec 88	9.28
4	M.P.	Kheda	MPUVN	0.50	5	100	S.R	18 Feb 90	9.43
5	Orissa	Puri - I	OREDA	0.55	10	55	S.R	01 May 86	9.59
		Puri - II	OREDA	0.55	10	55	S.R	01 Jan 88 (0.44) 01 Mar. 88 (0.11)	2.16
6	Tamil Nadu	Tuticorin-I	TNEB	0.55	10	55	S.R	18 Jan 86	41.25
		Tuticorin-II	TNEB	0.55	10	55	S.R	21 Nov 86 (0.33)	32.52
		Kayathar-I	TNEB	1.35	15	90	S.R	07 Apr 88 (1.35)	87.55
				1.20	6	200	P.C	12 June 89 (0.40) 31 Mar 90 (0.80)	46.23
		Kayathor-II	TNEB	6 0	30	200	S.R	25 Jan 90	220.30
		Muppandal	TNEB	4.0	20	200	S.R	31 Mar 90	166.23
7	Karnataka	Talacauvery	KSIIDC	0.55	5	110	S.R		-
				31.60					1022.58

S.R. = Stall Regulated

P.C. = Pitch Regulated

Table V.4.8

Private wind turbines installed so far in the country.

Pandian Chemicals Ltd., Madurai	2 x 250 kW = 500 kW
Tamil Nadu Chlorates Ltd., Madurai	2 x 250 kW = 500 kW
Metal Powder Co. Ltd., Madurai	2 x 250 kW = 500 kW
Sayed Cotton Mills (P) Ltd., Tirunelvelli	1 x 250 kW = 250 kW
Standard Windfarm, Sivakasi	1 x 250 kW = 250 kW
Standard Fireworks Ltd., Sivakasi	1 x 250 kW = 1000 kW
The Bell Pins Manufacture Co., Tirunelvelli	1 x 250 kW = 250 kW
Style Fasteners, Tirunelvelli	1 x 250 kW = 250 kW
Rajshree Spinning Mills, Coimbatore	1 x 250 kW = 250 kW
The Gomathy Mills, Tirunelvelli	2 x 250 kW = 500 kW
The Metal Powder Co., Madurai	2 x 250 kW = 500 kW
Total	**4.75 MW**

Table V.4.9 Capacity utilization factor of windfarms installed in India.

Site	Capacity (kW)	CUF % 1987	1988	1989	1990	Average
Mandvi I	550	17.78	15.83	13.55	14.42	15.39
Tuticorin I	550	16.60	13.53	13.66	14.41	14.55
Okha	550	17.21	11.94	9.73	13.29	13.06
Puri I	550	9.3	5.16	1.24	-	5.2
Deogarh I	550	10.86	9.7	8.28	7.3	9.03
Tuticorin II	550	16.2	14.3	15.29	16.18	15.49
Kayathar IA	1350	-	-	19.33	22.27	20.28
Kayathar IB	1200	-	-	-	23.5 (90-91)	23.5
Mandvi II	500	-	-	-	12.0	12.0
Puri II	550	-	-	-	4.15	4.15
Deogad II	550	-	-	5.65	7.28	6.46
Tirumalla	550	-	-	-	9.7	9.7
Okhamadhi	1800	-	-	-	12.00	12.18
Kheda	500	-	-	-	10.08 (90-91)	10.08
Lamba	10000	-	-	-	9.18 (90-91)	9.18
Kayathar II	6000	-	-	-	24.81 (90-91)	24.81
Muppandal*	4000	-	-	-	29.83 (90-91)	29.83

* Two machines of 200 kW each were not functioning in Muppandal in peak generation period of July / August.

Table V.4.10

Status of the windpump demonstration programme (As on February 28, 1989).

	No. of wind-pumps installed until Jan.31, 1988	Additions between February 1, 1988 and February 28, 1989	Total no.installed until February 28,1989
Andhra Pradesh	235	33	268
Bihar	152	10	162
Goa	6	-	6
Gujarat	94	9	103
Haryana	30	1	31
Himachal Pradesh	9	3	12
Jammu & Kashmir	3	-	3
Karnataka	24	19	43
Kerala	4	5	9
Madhya Pradesh	164	-	164
Maharashtra	132	-	132
Nagaland	4	-	4
Orissa	269	32	301
Punjab	77	-	77
Rajasthan	76	25	101
Tamil Nadu	325	185	510
Uttar Pradesh	252	10	262
West Bengal	15	-	15
Tripura	2	-	2
Union Territories			
Andaman & Nicobar	14	5	19
Chandigarh	4	-	4
Delhi	45	31	76
Pondicherry	10	-	10
Total	**1946**	**368**	**2314**

Source: Ministry of Energy, DNES, Annual Report, 1989-90.

Table V.4.11
Indigenously designed windpumping systems*.

Manufacturer	Salient design features
Indoxy	Vertical axis windmill'S' type rotor, diaphragm pump.
Pooja	Horizontal axis windmill, APOLLY Design.
Surya Shakti	Horizontal axis windmill, 1.5 metre plastic rotor, 6 metre tower, special piston pump.
BHEL	Horizontal axis windmill, multivane, 10 cm diametre brass liner pump.
BHEL	Horizontal axis windmill, modified and strengthened for cyclone prone areas.
BHEL	Horizontal axis windmill with provision for manual operation during non-windy periods.
Samira	---
LGB	---

* Under field testing.
Source: Ministry of Energy, DNES, Annual Report, 1989-90.

Biogas programme

Biogas is an important renewable source of energy and is produced through anaerobic digestion of organic materials like cattle dung, human wastes and different types of biomass. It provides a clean and smokeless fuel for domestic cooking, and the biogas plant also produces enriched and high quality organic fertilizer. The biogas programme has become increasingly popular in rural areas all over the country.

The National Project on Biogas Development (NPBD) for the promotion of family size biogas plants, was initiated and has consistently accounted for over half of the final allocation in the renewable sector. During 1987/88 1 lakh, 73 thousand plants were installed against the target of 1 lakh, 20 thousand. Some steps have been taken since 1984/85, to improve the performance of family size plants. These measures include technical improvements in the design, training support, repair and maintenance facilities

and regular monitoring and evaluation. The users however, still continue to be subsidized; which indicates that commercial viability of the technology remains to be established in the existing energy system in India.

In addition, the Government has also initiated a demonstration programme to familiarize users with community size biogas plants. It is an integrated decentralized waste recycling and energy generation system, for providing rural needs for cooking, water pumping and sanitation. In order to extend this facility to more villages, the subsidy pattern was modified, beginning November 1986: (i) for community biogas plants (CBPs), the central assistance is given upto 15% of the capital cost and maintenance for two years and (ii) for institutional biogas plants (IBPs), the central financial assistance was reduced from 75% to 70%.

The R & D programme aims to develop more economical designs of digestors, burners and biogas engines. Other R & D projects are to develop designs for using water-hyacinth and aquatic biomass as feedstock. Still others are to develop digestors in which food processing wastes, pulp and a variety of industrial effluents can be used as feedstock. Simultaneously, microbiological studies are in progress, in which the enhancement of biogas production through selective microbial action is being studied.

Table V.5.1

State/year-wise number of biogas plants installed

National projects on biogas development (up to 31.03.91)

State/U.T./Agency	Up to-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	Total
Andhra Pradesh	29662	19120	19181	9800	8378	3186	8578	97905
Arunachal Pradesh					24		28	52
Assam	925	457	1245	2107	2015.	1808	1191	9748
Bihar	19748	9744	9642	8350	6379	4690	4313	62866
Goa	530	156	143	110	231	278	216	1664
Gujarat	22622	13563	14534	11657	14227	16305	26537	119445
Haryana	7834	2266	2499	1580	1919	2031	1948	20077
Himachal Pradesh	3530	2650	2850	3201	3505	5086	3668	24490
Jammu & Kashmir	126	155	132	132	106	57	185	893
Karnataka	19571	8361	11324	9457	9380	7875	6586	72554
Kerala	6300	3937	3424	2937	3148	3725	3700	27171
Madhya Pradesh	14959	5668	4539	2976	4759	4431	3637	40969
Maharashtra	86340	60344	59553	60170	54191	50064	50384	421046
Manipur	21			16	112	190	77	416
Meghalaya	71			6	30	60	52	219
Mizoram	14	115	152	90	114	106	120	711
Nagaland	49	3	16	5	51			124
Orissa	5889	5429	4434	6094	9377	17184	13022	61429
Punjab	4969	1807	2478	1409	2062	2077	2393	17195
Rajasthan	13774	5398	4371	3840	3738	3743	3518	38382
Sikkim	31		25	55	90	163	175	539
Tamil Nadu	31260	19514	22079	23128	16488	14627	9983	137079
Tripura					39	75	50	164
Uttar Pradesh	69203	28096	31495	19198	19261	13553	17063	197869
West Bengal	5910	3268	6515	7184	7200	10397	8702	49176
A & N Islands	3	10	40	19	15	11		98
Chandigarh	52	5	5	5	5	5	1	78
D & N Haveli	72	11	15	14	11	10	10	143
Delhi	188	80	112	100	63	35	22	600
Pondicherry	277	65	30	19	35	21	25	472
Total	**343930**	**190222**	**200833**	**173659**	**166953**	**161793**	**166184**	**1403574**

Installation:

Maximum in Maharastra (421046)

Minimum in Arunachal Pradesh (52)

Source: Ministry of Energy, DNES.

Table V.5.2

Summary information on evaluation survey studies conducted by independent agencies in 1987-88 and 1988-89.

Surveying agency	States covered	Sample size (no. of plants)	Status of plants: Working (%)	Non-working due to: Operational problems (%)	Structural problems (%)
Kirloskar Consultant Pvt. Ltd., Pune	Haryana	520	96.7	1.7	1.6
	Himachal Pradesh	520	92.2	5.5	2.3
	Rajasthan	940	52.1	37.9	10.0
Besant Raj Consultants Ltd., Madras	Tamil Nadu	2011	93.0	4.7	2.3
	Kerala	706	95.4	3.4	1.2
	Pondicherry	30	75.0	17.8	7.2
Indian Institute of Management, Ahmedabad	Bihar	1671	72.4	23.8	3.8
Centre for Studies in Decentralised industries, Bombay	Karnataka	1495	94.1	4.0	1.9
	Gujarat	1612	81.7	11.2	7.1
Operations Research Group, Baroda	Maharashtra	2309	92.5	6.4	1.1
	Orissa	500	91.1	5.3	3.6
West Bengal Consultancy Orgn. Ltd., Calcutta	West Bengal	630	89.2	5.6	5.2
National Council for Applied Economic Research, New Delhi	Andhra Pradesh	3388	92.9	5.3	1.8
	Madhya Pradesh	1028	70.1	24.9	5.0
	Punjab	337	92.9	5.2	1.9
	Assam	124	95.7	4.3	-
	Mizoram	115	94.7	4.4	0.9
	Meghalaya	52	54.3	45.7	-
	Manipur	4	75.0	25.0	-
	Nagaland	3	66.7	33.3	-
	Jammu & Kashmir	25	36.0	56.0	8.0
	Delhi	22	10.5	84.2	5.3
Agricultural Finance Corporation, Bombay	Uttar Pradesh	1800	60.6	27.6	11.8
Total/average		**19842**	**84.3**	**11.7**	**4.0**

Source: Ministry of Energy, DNES, Annual Report, 1989-90.

Table V.5.3

Independent evaluation of biogas plant installation (%) by different organizations.

Institution	**Functional plants**	**Non-functional plants**
Centre of Science for villages, Wardha, Maharashtra	48	52
Directorate of Agriculture	64.3	35.7
Institute of Health Management, Pachod, Maharashtra	4.3	95.6
Institute of Rural Management, Anand, Gujarat	40	60
Indian Institute of Management, Ahmedabad, Gujarat		
Janata plants	60	40
KVIC plants	89	11
Khadi and village Industries Commission	70	30

Source: P. Venkata Ramana, Biogas Programme in India, TERI's Information Digest on Energy, Vol.I, No.3 (1991).

Table V.5.4
State-wise evaluation of biogas plant (%) by the Comptroller and Auditor General.

States	Functional plants	Non-functional plants	Non-commissioned plants	Defective plants	Incomplete plants	Non-existent plants
Andhra Pradesh	69	12		19		
Haryana	41.85		41.3	4	12	0.85
Himachal Pradesh	62.2	37.8				
Madhya Pradesh	65.3	34.7				
Orissa		100				
Pondicherry		58.33	41.67			
Punjab	32.3	43.8		23.9		
Rajasthan	30.5	5.65	41.8		19.2	2.85
Tamil nadu		14.8			85.2	
Uttar Pradesh	89.6	10.4				
West Bengal		100				
KVIC	72.5	21.2				6.3

Source: P. Venkata Ramana, Biogas Programme in India, TERI's Information Digest on Energy, Vol.I, No.3 (1991).

Table V.5.5: Performance of community biogas plants.

Village	Capacity (m^3)	Year of commission	Status	Capacity utilization	Reasons/comments
Kodumunja (Andhra Pradesh)	128	1977	Dysfunctional		Structural failure
Fateh Singh Ka Purwa (Uttar Pradesh)	80	1978	Dysfunctional		Lack of dung supply
Kubarthal (Gujarat)	NA	1980	Dysfunctional		Village conflicts
Dhaniv (Maharashtra)	114	1981	Operational	17	Shortage of dung*
Kirkitwadi (Maharashtra)	94	1982	Dysfunctional		Village conflicts
Purva (Karnataka)	85	1982	Operational	NA	
KG Patti (Tamil Nadu)	94	1982	Operational	15	Semi-arid region*
Masudpur (Delhi)	194	1982	Operational	58	Run as on IBP
Hosala (Karnataka)	74	1982	Operational	14	Shortage of dung*
Khoraj (Gujarat)	140	1983	Dysfunctional	42	Caste politics
Janepur (Uttar Pradesh)	90	Never commissioned			Structural failure
Saragaon (Rajasthan)	85	Never commissioned			No dung, no water
Veeranjaneyapuram (Andhra Pradesh)	114	Never commissioned			No water
Mucherla (Andhra Pradesh)	65	NA	Operational	22	Shortage of dung*
Khandia (Gujarat)	85	1985	Operational	20	Part of Urjagram
Motipura (Gujarat)	255	1986	Operational	100	Has a strong leader
Methan (Gujarat)	630	1987	Operational	100	Cohesive village
Teekli (Haryana)	170	1987	Dysfunctional		Panchayat refused to take over
Mehdoodan (Punjab)	110	1985	Operational	47	Shortage of dung
Chabwal (Punjab)	170	1985	Dysfunctional		No labour to carry dung
Peharkalan (Punjab)	170	1985	Operational	67	Shortage of dung
Ablowal (Punjab)	170	1985	Operational	67	
Passiana (Punjab)	170	1985	Operational	73	
Pandori (Punjab)	170	1985	Dysfunctional		No dung supply
Hambran (Punjab)	150505	1985	Operational	47	Shortage of dung
Talwandi Jattan (Punjab)	NA	NA	Operational	NA	Shortage of dung
Barbala Kalan (Punjab)	NA	NA	Operational	NA	Shortage of dung
Karnal (Punjab)	170	1985	Dysfunctional		No dung
Dharamgarh (Punjab)	NA	NA	Operational	NA	Shortage of dung
Banur (Punjab)	NA	NA	Operational	NA	Shortage of dung
Palahi (Punjab)	NA	NA	Operational	NA	Shortage of dung
Nathuchak (Punjab)	NA	NA	Operational	NA	
Lokha (Punjab)	NA	NA	Dysfunctional	NA	No dung
Kheri Bhai Ki (Punjab)	85	1986	Operational	NA	Strong leadership, compact village

* Present status unknown

NA: Not available

Source: P. Venkata Ramana, Biogas Programme in India, TERI's Information Digest on Energy, Vol.I, No.3 (1991).

Table V.5.6

Pattern of central subsidy for biogas plants (as on 31.8.1990) (Rupees).

Capacity of plant (cu.m. of gas/day)	For North-Eastern states*	Plain areas of Assam, Western ghats**	SC/ST and desert distt.	For other areas	
				Small & marginal farmers including landless labourers	For all others
1	-	-	1500	1500	1200
2	4400	3100	2600	2600	1700
3	5500	3800	3000	-	2100
4-10	6600	4400	3000	-	2200

* Excludes plains of Assam but includes Sikkim, J&K, Himachal Pradesh and eight hilly districts of UP (excluding Terrai region of two districts).

** Includes Terrai districts of two hilly districts of UP, notified hilly areas and Andaman & Nicobar Islands.

Source: Ministry of Energy, DNES, Annual Report, 1990-91.

Table V.5.7

State-wise distribution of community biogas systems (upto March 1990).

State	Community biogas plants	Institutional biogas plants	Nightsoil biogas plants	Total
Andhra Pradesh	21	42	3	66
Gujarat	23	31		54
Madhya Pradesh	41	22		63
Maharashtra	36	29	4	69
Punjab	69	11		80
Rajasthan	5	29		34
Tamil Nadu	4	27		31
Utter Pradesh	35	28		63
Others	20	24		44
Total	**254**	**233**	7	**494**

Source: P. Venkata Ramana, Biogas Programme in India, TERI's Information Digest on Energy, Vol.I, No.3 (1991).

Improved chulhas

The main objectives of the national programme on improved chulhas, which was launched by the DNES on April 1, 1985, are: (i) to conserve and optimize the use of fuelwood to reduce deforestation and to alleviate the drudgery of women in rural areas;

(ii) to create a work-force of trained persons who are competent to construct/install improved models of chulhas, thereby generating employment in rural areas; (iii) to introduce training programmes for training master craftpersons in the construction of improved chulhas; and (iv) to accelerate technical and R & D activities so as to bring better models on the list approved for propagation.

There are two major types of chulhas which are being disseminated: (i) fixed model chulhas, made of clay, brick etc.; and (ii) portable models, made of steel. The minimum thermal efficiency of a fixed chulha should be 20% and of a portable one should be 25%. Other criteria necessary for a chulha to satisfy to be considered for propagation under the national programme are (i) it should be cheap and easy to construct; and (ii) it should be acceptable to the user.

The approved models are still subsidized by the DNES. Along with fuel savings, a need has been felt to study the pollutant emissions of the improved chulhas.

More than 7 million chulhas have been installed in the Seventh FYP period. The target for 1991/92 is installation of 1.9 million chulhas; and the emphasis is expected to be more on installation of community/commercial/institutional chulhas.

Table V.6.1

No. of improved chulhas installed.

State/UTs	Annual target (1990-91)	Achievements up to Dec 1989
Andhra Pradesh	10800	23499
Assam	45000	7200
Bihar	108000	47297
Gujarat	81000	52834
Haryana	54000	33206
Himachal Pradesh	45000	28252
Jammu & Kashmir	36000	34972
		contd...

Table V.6.1 (contd.)

No. of improved chulhas installed.

State/UTs	Annual target (1990-91)	Achievements up to Dec 1989
Karnataka	90000	46724
Kerala	45000	31120
Madhya Pradesh	144000	147289
Maharashtra	117000	88387
Manipur	5400	2355
Meghalaya	4500	N.A
Nagaland	2700	N.A
Orissa	54000	29239
Punjab	45000	63851
Rajasthan	130500	73498
Sikkim	3600	1822
Tamil Nadu	90000	80365
Tripura	2700	1041
Uttar Pradesh	189000	114245
West Bengal	49500	20924
Andaman & Nicobar	4500	4010
Arunachal Pradesh	1800	N.A
Chandigarh	450	N.A
Dadra & Nagar Haveli	900	300
Delhi	22500	16641
Goa	9000	7130
Lakshadweep	2250	1306
Mizoram	2250	1650
Pondicherry	1800	1625
Daman & Diu	450	N.A
Others	176200	85816
Total	1672000	1046598

Note: Likely achievement by 31st March is expected to be the same as targeted.

Source: Ministry of Energy, DNES, Annual Reports - 1989-90, 1990-91.

Table V.6.2
Pattern of subsidy for improved chulhas*.

	Subsidy for scheduled tribes, scheduled castes and hilly areas	**Subsidy for other areas**
Fixed model of chulha	Rupees ten contributed by the beneficiary towards the hard-ware cost and installation charges. Remaining cost covered by DNES.	
Portable model of chulha	75% of the approved cost of a model	50% of the approved cost of a model

* In addition a supervisory fee of Rs.5/- is paid to the trained worker on the construction/installation of each stove.

Source: Ministry of Energy, DNES, Annual Report, 1989-90.

Small hydropower stations

Until the recent past, small hydro power was the most unappreciated and most neglected energy resource, although it has been known for over a century. The small hydro potential in the country is estimated at about 5000 MW comprising: (i) 2000 MW potential with small discharges and high heads, as in hilly areas; and (ii) 3000 MW potential with large discharges under comparatively low heads, as on small rivers, irrigation outlets, canal falls etc.

One of the major disadvantages of small hydro projects is stated to be the high capital cost. This is particularly true for projects which are constructed in remote and hilly areas, where infrastructural facilities are limited. The DNES has therefore undertaken a research, development and demonstration programme of small hydro projects. Five demonstration projects are now in various stages of completion.

Table V.7.1

Small hydro demonstration programme.

Location	Capacity (kW)	Net head (metres)	Design discharge (cumecs)	Remarks
Jubbal (Himachal Pradesh)	1 X 100 (Synchronous) +2 X 25 (Induction)	80	0.17	Commissioned in June, 1985; high head.
Manali (Himachal Pradesh)	1 X 100 (Synchronous) +1 X 100 (Induction)	40	0.8	Commissioned in June, 1985; medium head.
Sonepat - I (Haryana)	1 X 100 (Synchronous) +1 X 100 (Induction) +1 X 100 (synchronous)	1.8	31.15	The first unit was commissioned in January 1988; the second is in the process of commissioning; and the third is being installed; ultra low.
Bhatinda (Punjab)	1 X 100	2.85	8.5	Expected to be commissioned in 1988/89; low head.
Saharanpur (Uttar Pradesh)	2 x 125	5.5	5.66[a] 2.83[b]	Low Head.

[a]. For 17 hours.

[b]. For 7 hours.

Source: Ministry of Energy, DNES, Annual Report, 1989-90.

Table V.7.2

Proposed small hydel schemes on canal falls.

	Capacity MW	**Cost (crore Rs.)**	**Number of sites**
Bihar	1.00	2.50	1
Orissa	0.01	0.03	1
Sub-total	**1.01**	**2.53**	**2**
Haryana	24.00	52.30	20
Punjab	29.30	60.90	21
Sub-total	**53.30**	**113.20**	**41**
Andhra Pradesh	40.60	96.30	8
Karnataka	17.00	32.00	8
Kerala	9.70	25.20	6
Tamil Nadu	2.40	3.40	2
Sub-total	**69.70**	**156.90**	**24**
Gujarat	15.00	38.50	13
Madhya Pradesh	9.70	21.80	12
Sub-total	**24.70**	**60.30**	**25**
Totals	**148.71**	**332.93**	**92**

Source: DNES, 1989, Mini Hydro Power: Proposed Eighth Plan Implementation Programme, Vol.1, p25-26.

Table V.7.3

Proposed and ongoing mini hydel schemes.

	DPR not ready capacity	Cost (crore Rs.)	DPR ready capacity (MW)	Cost (crore Rs.)	Targeted capacity (MW)	Cost (crores Rs.)	Operational capacity (MW)	Cost (crore Rs.)
Bihar	25.10	64.70	1.00	2.50				
Orissa	14.60	29.90	0.01	0.30			0.04	0.80
West Bengal	38.20	70.50						
Sub-total	**77.90**	**165.10**	**1.01**	**2.80**	**0.00**	**0.00** —	**0.04**	**0.80**
Haryana			24.10	52.30	0.40	1.30		
Himachal Pradesh	8.30	12.40	0.50	1.30				
Jammu & Kashmir	63.00	103.90	23.70	62.30	7.60	28.80		
Punjab	41.90	124.20	29.30	60.90				
Uttar Pradesh	99.00	208.60	4.40	11.60	16.70	35.70	8.60	20 90
Sub-total	**212.20**	**449.10**	**57.90**	**136.10**	**24.30**	**64.50**	**8.60**	**20.90**
Assam	9.60	15.60	6.00	7.80				
Manipur	7 00	13 00						
Meghalaya	5.20	13.80						
Nagaland	0.50	1.00	7.80	18.00	0.80	2.30	2.50	5 80
Sikkim	9.10	17.00						
Tripura	4.40	10.10						
Arunachal Pradesh	40.30	76.00			6.80	14.40	14.10	27.80
Mizoram	1.50	11.10						
Sub-total	**77.60**	**157.60**	**13.80**	**25.80**	**7.60**	**16.70**	**16.60**	**33.60**
Andhra Pradesh	30.30	71.80	12.60	28.30				
Karnataka	6.90	17.60	17.00	32.00	24.10	64.10		
Kerala	112.00	247.50	9 70	25 20	10 00	12 90		
Tamil Nadu	77.40	125.50	7.90	10.30	4.80	9.90		
A.& N. Island	3.00	4.50						
Sub-total	**229.60**	**466.90**	**47.20**	**95.80**	**38.90**	**86.90**	**0.00**	**0.00**
Gujarat	8 30	25.30	18.51	46.00	2.00	6.60		
Madhya Pradesh	27.50	60.30	9.70	21.80	3.80	9.60		
Maharashtra	61.00	142.10						
Rajasthan	0.80	2.00	8.60	21.70	1 00	3.30		
Goa,Daman & Diu	1.50	2.30						
Sub-total	**99.10**	**232.00**	**36.81**	**89.50**	**6.80**	**19.50**	**0.00**	**0.00**
Totals	**696.40**	**1470.70**	**180.82**	**402.30**	**78.00**	**188.90**	**25.24**	**55.30**

DPR: Detailed project report.

Source: DNES, 1989, Mini Hydro Power: Proposed Eighth Plan Implementation Programme, Vol.1, p23-24.

Environmental implications of energy use

Environmental implications of energy use

Environmental effects of energy use

Until recently, energy planning in India was done with little concern for environmental effects of energy production, conversion, transportation and utilization. However, the implications of one or more of these steps in the energy chain may be particularly severe in areas of concentrated population and/or activity. Metropolitan cities, industrial townships and villages around large mining centres are some such areas.

Among the environmental effects that may be considered, is the impact of pollutant emissions on human health and ecology. Although it is difficult to relate such impacts to exposure times and concentration levels of various pollutants, some indicative information presented in Tables VI.1.1 through VI.1.3 highlights this important issue.

Tables VI.1.4 through VI.1.8. also show that pollutant emissions and other environmental implications are indeed associated with energy utilization. It has been observed that the very process of coal extraction leads to siltation, soil erosion, coal dust in air, and so on. Some of these issues may not be of immediate consequence, but are important nevertheless from a long term point of view. Likewise, coal transportation/processing, combustion and ash disposal are also known to contribute to environmental pollution.

Similar impacts may be observed with the utilization of petroleum products and traditional fuels as well. Burning fossil fuels and biomass-based fuels introduces large quantities of carbon-dioxide into the atmosphere. Although carbon-dioxide is not formally classified as a pollutant, it can introduce climatic changes in the long run (e.g. rising temperatures), if its concentration levels in the atmosphere keep increasing. Such changes may have severe consequences for tropical countries and may be highly unpredictable, uncontrollable and perhaps irreversible. This should be a major concern in India, where forests (which fix atmospheric carbon dioxide) are depleting at an alarming rate.

Besides carbon-dioxide, the use of hydrocarbon fuels also results in the emission of carbon-monoxide, unburned hydrocarbons, nitrogen oxides and particulates. Exhausts from transport vehicles include all these pollutants; a fact which is of relevance to major cities and towns in India. In particular, as the number of two- and three-wheelers has increased rapidly during the last decade (and is likely to continue in to the foreseeable future), special emphasis should be placed on a programme to limit the emission of unburned hydrocarbons, as also of carbon-monoxide.

Pollutant emissions from various types of cooking stoves using fuelwood, crop residues, cowdung cakes, or even coal and kerosene, can be considerable. This is of particular concern to developing countries like India, where there is ever increasing evidence that a large number of people who are exposed to significant air pollutants generated from open combustion of biomass, may be at a relatively higher risk of contracting several diseases.

Table VI.1.1

Observed effects of particulates.

Concentration (mg/cu.m.)	Measurement conditions	Effects
60-180	Annual geometric mean with moisture	Acceleration of corrosion of steel and zinc panels.
75	Annual mean	USEPA 1974 air quality standard.
150	Relative humidity less than 70%	Visibility reduced to 8 Km.
100-150	-	Direct sunlight reduced to one-third.
80-100	With Sulphation levels of 30 mg/cm^2/month	May increase death rate of persons over 50.
100-130	With SO_2>4120 ug/cu.m.	Children likely to experience increased incidence of respiratory disease.
200	24-hour average and SO_2>250 ug/cu.m.	Illness of industrial workers may increase absenteeism.
260	Maximum once in 24 hrs	USEPA 1974 air quality standard.
300	24 hr maximum and	Symptoms of chronic SO_2) 630 ug/cu.m. bronchitis patients are likely to worsen.
750	24 hr average and SO_2>715 ug/cu.m.	Excessive no. of deaths and considerable increase in illness may occur.

Source: National Air Pollution Control Association, "Air Quality Criteria for Particulate Matter", AP-49, Washington, D.C., HEW, 1969.

Table VI.1.2

Health effects of carbon monoxide (CO) and carboxyhaemoglobin (COHb).

Concentration	Exposure	Effects
CO (ppm)		
9	-	USEPA ambient air quality standard.
50	6 weeks	Structural changes in heart and brain of animals.
50	50 minutes	Changes in relative brightness and visual activity.
50	8-12 hours	Impaired performance on psycho-motor tests in non-smokers.
COHb Level (%)		
< 1		No apparent effect.
1-2		Some evidence of effect on behavioral performance.
2-5		Central nervous system effects-Impairment of time-interval discrimination, visual activity brightness discrimination, and certain other psychomotor functions.
> 5		Cardiac and pulmonary functional changes.
10-80		Headaches, fatigue, drowsiness, coma, respiratory failure, death.

Source: Wark, K. and Warner, C.F. "Air Pollution: Its Origin and Control", Harper and Row, New York, 1976.

Table VI.1.3

Effects of SO_2 at various concentrations.

Concentration (ppm)	Duration	Effects
0.03	annual	USEPA 1974 air quality standard, chronic injury.
0.037-0.092	annual	Accompanied by Smoke at 185 ug/cu.m., increased frequency of respiratory symptoms and lung diseases.
0.11-0.19	24 hour	With low particulate level, rise in hospital admissions of elderly for respiratory symptoms, increased metal corrosion.
0.19	24 hour	With low particulate level, increased mortality may occur.
0.25	24 hour	Accompanied by smoke at a concentration of 750 ug/cu.m., increased daily deaths may occur (U.K. data).
0.3	8 hour	Some trees show injury.
0.52	24 hour	When accompanied by particulates, increased mortality may occur.

Source: National Air Pollution Control Administration,"Air Quality Criteria - for Sulphur Oxides", AP-50, Washington, D.C., HEW, 1970.

Table VI.1.4
Environmental impacts associated with the different stages of the coal life cycle.

Stages	Impacts mediated through		
	Air	**Land**	**Water**
1.Extraction	Coal dust, (surface mines), occupational hazards	Disturbed Land, Soil erosion	Chemical mine drainage, siltation
2.Transport & processing	Coal dust, Noise,	Land requirements	Only for slurry Diesel exhaust pipelines
3.Combustion	Particulates (Trace Elements, Radionuclides, polycyclic organic matter) and gases (SO_x, NO_x, CO_x)	Combustion Products; Fallout including Acid Rain. Reduction in plant productivity	Thermal discharge, Combustion Products, Fallout including Acid Rain, Reduction in aquatic productivity
4.Ash disposal	-	Land requirements	Possibility of leachates (especially toxic trace metals & radionuclides)

Source: Dilip R. Ahuja and J.D. Pandya, "Power Industry", in P.L. Diwakar Rao (ed.), Pollution Control Handbook, Utility Publications Ltd., Secundrabad, 1986.

Table VI.1.5
Forest under coal mines (ha).

Region	**Forest area up to 1989-90**	**Additional requirement of forest area 1990-91 to 1994-95**
Northern	-	-
Western	18788	9244
Southern	11379	7008
Eastern	24666	5045
North-Eastern	1180	45
All India	**56013**	**21342**

Source: GOI, 1990. Report of the Working Group on Coal and Lignite for the 8th Plan, Planning Commission.

Table VI.1.6

Urban air pollution from vehicular emissions.

Emissions	**Source of emission**	**Contribution of the source in total emissions**	**Remarks**
1.Carbon monoxide (CO)	Petrol driven vehicles	85%	Contribution of two wheelers is expected to rise.
2.Unburned Hydro-carbons	Two and Three Wheelers	35-65%	Contribution of two and three wheelers expected to increase to 80% by 1991-92.
3.Nitrogen Oxides (NO_x)	Diesel driven vehicles	> 90%	-
4.Particulates	Diesel driven vehicles	-	-

Source: B.Bowonder in P.L. Diwakar Rao (ed.), Pollution Control Handbook, Utility Publications Ltd., Secundrabad, 1986.

Table VI.1.7

Emission factors for different pollutants from cooking stoves for various Fuel-Stove combinations (g/kg).

Stove type fuel and pollutant	**Conventional metal****	**Improved metal****	**Improved mud****
Fuelwood			
TSP	1.3 - 2.7	1.1 - 3.8	1.8 - 2.1
CO	13 - 22	25 - 62	32 - 48
Crop residues			
TSP	2.1 - 5.0	2.1 - 12.0	3.5
CO	20 - 39	23 - 114	48
Dungcakes			
TSP	4.1 - 5.3	4.2 - 7.8	7.4
CO	11 - 16	34 - 67	46

** One port.

Source: TERI, Evaluation of Performance of Cookstoves In Regard to Thermal Efficiency and Emissions from Combustion, submitted to Ministry of Environment, Forests and Wildlife, Government of India, Feb. 1987.

Table VI.1.8

Smoke exposures and concentrations due to traditional and improved cookstoves with flues*.

Location	Pollutant	Traditional stoves		Improved stoves	
		No. of expts	Mean	No. of expts	Mean
Personal monitoring					
Nepal					
a. Two mid-hill villages	TSP	22	3.1 mg/cu.m.	27	1.1 mg/cu.m.
India					
b. Two Gujarat villages	TSP	21	6.4 mg/cu.m.	14	4.6 mg/cu.m.
	BAP	21	3.7 ug/cu.m.	14	2.4 ug/cu.m.
c. Eight Gujarat villages (3 stoves)	TSP	45	4.4 mg/cu.m.	57	4.0 mg/cu.m.
One stove type (4 villages)	TSP	21	3.6 mg/cu.m.	23	3.9 mg/cu.m.
d. One Haryana village(f)	TSP	51	3.2 mg/cu.m.	36	2.8 mg/cu.m.
d. Two Karnataka villages (f,g)	TSP	39	3.5 mg/cu.m.	40	2.6 mg/cu.m.
Area monitoring[@]					
Nepal					
a. Two mid-hill villages	CO	27	300 ppm	26	67 ppm
7 - day means					
(Kitchen)	NO_2	5	0.26 ppm	5	0.04 ppm
(Bedroom)	NO_2	4	0.02 ppm	4	0.04 ppm
(Kitchen)	HCHO	5	0.33 ppm	4	0.04 ppm
(Bedroom)	HCHO	4	0.04 ppm	4	0.13 ppm
India					
b. Eight Gujarat villages	CO	36	110 ppm	48	34 ppm
(3 stoves)	CO	27	120 ppm	30	43 ppm
One stove type (4 villages)					
c. One Haryana village(f)	CO	51	7 ppm	36	6 ppm
d. One Karnataka village (f,g)	CO	24	23 ppm	39	9 ppm
Simulated cooking (with area monitoring)					
Nepal	CO	16	600 ppm	28	400 ppm
		All new stoves		**Well-installed new stoves**	
	CO	28	400 ppm	11	100 ppm

* Except where noted, all measurement were taken during the cooking period in the dry season either by use of personal monitoring equipment worn by the cook or with stationary monitors placed nearby. TSP = total suspended particulates; BAP = bezo(a)pyrane; CO = carbon monoxide; NO2 = nitrogen dioxide; HCHO = formaldehyde.

@ since placement is so critical, comparisons should be done within and not between different studies

Sources:

a H. Reid, K.R. Smith, and B. Sherchand, "Indoor smoke Exposures from Traditional and Improved Cookstoves: Comparisons Among Rural Nepali Women, " Mountain Research and Development 6(4), 1986, pp 293-294.

b K.R. Smith, Biofuels, Air Pollution, and Health: A Global Review, Plenum Publishing Company New York City, 1987.

c K.R. Smith and M.B. Durgaprasad, "Difficulties in Achieving and Verifying Exposure Reductions in Village Households with Improved Biofuel-fired Cookstoves", in B. Seifert et al. (eds) Indoor Air'87 Institute for Water, Soil, and Air Hygiene, Berlin, 3, 1987, pp 115-120.

d J. Ramakrishna, "Cultural, Technological, and Environmental Factors Influencing Indoor Air Pollution in Rural India," in B. Seifert et al.(eds) Indoor Air '87, Institute for Water, Soil, and Air Hygiene, Berlin, 3, 1987, pp 34-39.

e S. Joseph et al, "A Preliminary Investigation into the Impact on Pollution Levels in Nepali Household by the Introduction of Chimney Stoves," Food and Agricultural Organization, Kathmandu, 1985.

f These measurements were taken in all three major seasons (summer, winter, monsoon).

g Also measured were exposures of women cooking with traditional stoves placed under a fireplace-style hood. With 24 measurements, the means were 1.6 mg/cu.m.3 (TSP) and 5 ppm (CO), which are significantly lower than both traditional stoves and, for TSP, the improved stove in the same villages.

National ambient air quality standards (NAAQS)

Faced with growing air pollution problems, a number of countries have established ambient air quality standards for certain critical pollutants, over the last fifteen years. As the knowledge base about adverse health effects at low levels of pollution - or about threshold levels below which there are no detectable effects - is poor, administrators have had considerable leeway within which to set such standards. In general, it is not possible to compare these standards across nations, because of differences in averaging times specified for maximum allowable concentrations. However, an attempt is made to compare India's national air quality standards with those of other countries.

India is the only country which has set standards for an averaging time period of eight hours, uniformly for all critical pollutants. For purposes of establishing NAAQS, the Government has classified the country into three distinct areas: A, B and C. The standards are most lenient for areas classified as A (such as wastelands); and most stringent for areas classified as C (such as certain cities). However, it is not clear whether the established standards for ambient air quality can be enforced, as only a few cities have air quality monitoring stations.

Table VI.2.1 gives the NAAQS for carbon monoxide (CO). The effects of CO poisoning are well known; and NAAQS for CO are generally set lower than what may be considered safe for normal healthy adults. However, it is important to realize that these standards may not be considered safe for patients with heart diseases (like angina), hemolytic anemia, people living at high altitudes, etc. Comparing the eight-hour standards between various countries, two things are apparent: one, the French standard is too high, and may not provide an adequate safety margin, and two, the standards in India and the east-European countries are too stringent.

Standards for total suspended particulates (TSP) are given in Table VI.2.2. Most countries have set standards for TSP (i.e., including all particles to a size of 100 microns), although inhalable particles (less than 10 microns), and respirable particles (less than 3 microns) are more relevant from the public health point of view. As larger particles normally dominate measurements, it is not clear whether the NAAQS for TSP are directly relevant from the point of view of public health -- China has set a different standard for inhalable particles. However, it may be noted that the variability of standards for TSP is much less than that for CO.

Standards for sulphur oxides are shown in Table VI.2.3. Sulphur oxides have significant effects on materials, vegetation and human health, and much attention has been paid to control them. The NAAQS standards however, have been set in most countries largely in view of public health effects.

NAAQS for nitrogen oxides are shown in Table VI.2.4. The major environmental implication of nitrogen oxides has been identified as acidification of precipitation. As for CO, the NAAQS for nitrogen oxides also show a high degree of variability.

Table VI.2.1

National ambient air quality standards for carbon monoxide (mg/cu.m.).

Country	**Averaging time (hours)**			
	0.5	**1**	**8**	**24**
India area A	-	-	5.0	-
India area B	-	-	2.0	-
India area C	-	-	1.0	-
Austria	-	38.9	10.3	-
Bulgaria	3.0	-	-	1.0
Canada (desirable)	-	15.0	6.0	-
Canada (acceptable)	-	35.0	15.0	-
China (class I&II)		-	-	4.0
China (class III)	20.0*	-	-	6.0
Czechoslovakia	6.0	-	-	1.0
Finland	-	40.0	10.0	-
France	114.5*	-	57.3	-
F.R.G.	-	40.0	10.0	-
Israel	35.0	-	11.5	-
Italy	57.2	-	22.5	-
Japan	-	-	23.0	11.5
Philippines	-	33.0	10.0	-
Rumania	6.0	-	-	2.0
U.S.A.	-	40.0	10.0	-
U.S.S.R.	3.0	-	-	1.0
Yugoslavia	3.0	-	-	1.0

* Maximum value allowed at any time.

Source: Dilip R. Ahuja, "National Ambient Air Quality Standards and Averaging Times" in Energy Environment Monitor, ENVIS Centre On Energy, TERI, Vol.2, No.2, September 1986.

Table VI.2.2

National ambient air quality standards for suspended particulates (mg/cu.m.).

Country	Averaging time (hours)						
	0.5	1	2	8	24	4380	8760
India area A	-	-	-	0.5	-	-	-
India area B	-	-	-	0.2	-	-	-
India area C	-	-	-	0.1	-	-	-
Austria zone I	-	-	-	-	0.12	-	-
Austria zone II	-	-	-	-	0.20	-	-
Canada (acceptable)	-	-	-	-	0.12	-	0.06
Canada (tolerable)	-	-	-	-	0.40	-	-
China class I	0.3*	-	-	-	0.15	-	-
China class II	1.0*	-	-	-	0.30	-	-
China class III	1.5*	-	-	-	0.50	-	-
Finland	-	-	-	-	0.15	-	0.08
France	-	-	-	-	0.15	-	-
F.R.G.	-	0.48	-	-	0.15	-	-
Hungary	-	-	-	-	0.20	-	-
Israel	-	-	-	-	0.20	-	0.075
Italy	-	-	0.75	-	0.30	-	-
Japan	-	0.20	-	-	0.10	-	-
Norway	-	-	-	-	0.15	0.06	-
Philippines	-	-	-	-	0.25	-	0.18
Rumania	0.5	-	-	-	0.15	-	-
Sweden	-	0.10	-	-	-	-	-
U.S.A. (primary)	-	-	-	-	0.26	-	0.075
U.S.A. (secondary)	-	-	-	-	0.15	-	0.06
U.S.S.R.	0.5	-	-	-	0.15	-	-
Yugoslavia	-	-	-	-	-	-	-

* Maximum value allowed at any time.

Source: Dilip R. Ahuja, "National Ambient Air Quality Standards and Averaging Times" in Energy Environment Monitor, ENVIS Centre On Energy, TERI, Vol.2, No.2, September 1986.

Table VI.2.3

National ambient air quality standards for sulphur oxides (mg/cu.m.).

Country	Averaging time (hours)					
	0.5	1	8	24	4380	8760
India area A	-	-	0.12	-	-	-
India area B	-	-	0.08	-	-	-
India area C	-	-	0.03	-	-	-
Austria zone I	0.15	-	-	0.10	-	-
Austria zone II	0.30	-	-	0.30	-	-
Bulgaria	0.50	-	-	0.05	-	-
Canada (desirable)	-	0.45	-	0.15	-	0.03
Canada (acceptable)	-		-	0.30	-	0.06
China class I	0.15*	-	-	0.05	-	0.02
China class II	0.50*	-	-	0.15	-	0.06
China class III	0.70*	-	-	0.25	-	0.10
Czechoslavakia	0.50	-	-	0.15	-	-
Finland	-	-	-	0.30	-	0.07
France	-	-	-	0.25	-	-
F.R.G.	-	0.40	-	0.14	-	-
Hungary	0.50	-	-	0.15	-	-
Israel	0.75	-	-	0.26	-	-
Italy	0.75	-	-	0.38	-	-
Japan	-	0.26	-	0.10	-	-
Norway	-	0.40	-	0.20	0.06	-
Rumania	0.75	-	-	0.25	-	-
Sweden	-	0.625	-	0.25	-	-
U.S.A. (primary)	-	-	-	0.365	-	0.08
U.S.A. (secondary)	-	1.30	-	-	-	-
U.S.S.R.	0.50	-	-	0.05	-	-
Yugoslavia	0.50	-	-	0.15	-	-

* Maximum value allowed at any time.

Source: Dilip R. Ahuja, "National Ambient Air Quality Standards and Averaging Times" in Energy Environment Monitor, ENVIS Centre On Energy, TERI, Vol.2, No.2, September 1986.

Table VI.2.4

National ambient air quality standards for nitrogen oxides (mg/cu.m.).

Country	Averaging time (hours)					
	0.5	1	8	24	4380	8760
India area A	-	-	0.12	-	-	-
India area B	-	-	0.08	-	-	-
India area C	-	-	0.03	-	-	-
Bulgaria	0.085	-	-	0.085	-	-
Canada A	0.4	-	-	0.2	-	-
China class I	0.1*	-	-	0.05	-	-
China class II	0.15*	-	-	0.1	-	-
China class III	0.3*	-	-	0.15	-	-
Finland	-	0.5	-	0.2	-	-
France	-	-	-	0.2	-	-
F.R.G.	-	1.0	-	-	-	-
Hungary zone I	0.15	-	-	0.05	-	-
Hungary zone II	0.5	-	-	0.15	-	-
Israel	1.0	-	-	0.6	-	-
Italy	0.6	-	-	0.2	-	-
Japan	-	-	-	0.1	-	-
Norway	-	0.4	-	0.2	0.1	-
Rumania	0.3	-	-	0.1	-	-
U.S.A.	-	-	-	-	-	0.1
U.S.S.R.	0.085	-	-	0.085	-	-
Yugoslavia	0.085	-	-	0.085	-	-

* Maximum value allowed at any time.

Source: Dilip R. Ahuja, "National Ambient Air Quality Standards and Averaging Times" in Energy Environment Monitor, ENVIS Centre On Energy, TERI, Vol.2, No.2, September 1986.

Table VI.2.5

Long term trends of ambient air TSP levels (1978-87).

City	Annual mean trend	95th percentile concentration trend
Ahmedabad	-	+*
Bombay	+	+
Calcutta	-	+
Cochin	+	+
Delhi	-	+
Hyderabad	-	+
Jaipur	+	-
Kanpur	-	-
Madras	-	-
Nagpur	-	-*

* significant at 5% level.

Source: Sunderesan, 1991 "Air Pollution: The Dangerous Dimensions", in the Hindu Survey of the Environment, 1991.

Table VI.2.6

Long term trends of ambient air SO_2 levels (1978-87).

City	Annual mean trend	95th percentile concentration trend
Ahmedabad	-	-
Bombay	-	-
Calcutta	-	+
Cochin	+	+
Delhi	+*	+
Hyderabad	-*	-*
Jaipur	-*	-*
Kanpur	-*	-*
Madras	-*	-*
Nagpur	+*	+*

* significant at 5% level.

Source: Sunderesan, 1991 "Air Pollution: The Dangerous Dimensions", in the Hindu Survey of the Environment, 1991.

Table VI.2.7

Long term trends of ambient air NO_2 levels (1978-87).

City	Annual mean trend	95th percentile concentration trend
Ahmedabad	-	-
Bombay	+	+
Calcutta	+	+
Cochin	+*	+*
Delhi	+*	+
Hyderabad	+*	+
Jaipur	-	-
Kanpur	+	+
Madras	-*	-
Nagpur	+	+*

* significant at 5% level.

Source: Sunderesan, 1991 "Air Pollution: The Dangerous Dimensions", in the Hindu Survey of the Environment, 1991.

Table VI.2.8

Air pollution in selected cities.

	City	Sulphur dioxide				Gravimetrically determined suspended particulate matter				Smoke			
		Site	Number of days over 150 ug/cubic meter			Site	Number of days over 230 ug/cubic meter			Site	Number of days over 150 ug/cubic meter		
		Years	Min	Avg	Max	Years	Min	Avg	Max	Years	Min	Avg	Max
North America													
Canada	Montreal	10	0	3	7	10	0	8	14	x	x	x	x
United States	Chicago	4	0	1	2	7	0	6	14	x	x	x	x
	Hasten	3	0	0	0	7	0	0	0	x	x	x	x
	New York	12	1	8	22	12	0	0	0	x	x	x	x
South America													
Brazil	Rio de Gainer	x	x	x	x	6	0	11	35	x	x	x	x
Chile	Santiago	9	0	19	55	x	x	x	x	9	11	102	299
Colombia	Cali	1	0	0	0	x	x	x	x	x	x	x	x
Venezuela	Caracas	8	0	0	0	x	x	x	x	8	0	0	0
Asia													
China	Beijing	8	0	68	157	8	145	272	338	x	x	x	x
	Shanghai	10	0	16	32	10	19	133	277	x	x	x	x
	Shenyang	7	43	146	236	13	117	219	347	x	x	x	x
Hong Kong	Hong Kong	10	0	15	74	x	x	x	x	11	0	3	18
India	Bombay	13	0	3	32	12	23	100	207	x	x	x	x
	Calcutta	8	0	25	85	8	189	268	330	x	x	x	x
	Delhi	12	0	6	49	12	212	294	338	x	x	x	x
Japan	Osaka	20	0	0	0	20	0	0	2	x	x	x	x
	Tokyo	15	0	0	0	15	0	2	4	x	x	x	x
Europe													
France	Gourdon	4	27	46	64	x	x	x	x	9	0	3	7
German, Fed.Rep.	Frankfurt	6	8	20	38	3	0	0	0	x	x	x	x
	Munich	3	0	0	1	x	x	x	x	x	x	x	x
Italy	Milan	8	6	29	167	x	x	x	x	x	x	x	x
Netherlands	Amsterdam	10	0	1	5	x	x	x	x	x	x	x	x
United Kingdom	Glasgow	5	4	14	21	x	x	x	x	5	2	6	8
	London	6	0	7	17	x	x	x	x	6	0	0	0
Oceania													
Australia	Melbourne	13	0	0	0	4	0	0	0	x	x	x	x
	Sydney	12	0	2	11	10	0	3	19	x	x	x	x
New Zealand	Auckland	12	0	0	0	x	x	x	x	12	0	0	0
	Christchurch	12	0	0	2	x	x	x	x	12	0	8	25

ug = microgram; 0 = zero or less than half the unit of measure.

X = not available

Source: World Resources Institute, Global Environment Monitoring System (GEMS)

Emission standards for Indian industry

Concern over pollution caused by industries has increased during recent years in India. The Department of Environment (GOI) has undertaken certain steps to check industrial pollution, which include an environmental impact assessment of development projects, and the establishment of emission standards for various industries. The emission standards are expressed as concentration of pollutants per unit volume of air under normal conditions (i.e. 25°C, 760 mm Hg pressure and 0% moisture).

The Central Board for the Prevention and Control of Water Pollution (CBPCWP), New Delhi, has prescribed emission standards for certain industries, within the framework of the Air (Prevention and Control of Pollution) Act, 1981. The prescribed standards are supposed to be reviewed from time to time, and may be revised taking into account the actual experience and monitoring data available. State Boards may adopt standards that are more stringent than those laid down by the Central Board, but they can not relax those standards. Standards prescribed for some of the industries are given below.

Standards are prescribed only for the most critical pollutants. They are mostly particulate matter, such as in the thermal power stations, iron and steel plants, cement plants and fertilizer plants. As sulphur-dioxide emissions are most critical in oil refineries, suitable standards are prescribed there. For other industries, the method prescribed for keeping sulphur-dioxide concentrations at ground level within reasonable limits, is to raise stack heights appropriately.

Table VI.3.1
Thermal power stations -- emission standards for particulate matter (mg/Ncu.m.)*.

Boiler size	Protected areas	Other areas**	
		Old	New
< 200 MW	150	600	350
> = 200 MW	150	-	150

* mg/normal cu.m. of flue gases.
** Electrostatic precipitator (ESP) help in the removal of particulate matter. BHEL came out with an improved ESP design in 1979. Therefore, all plants commissioned after Dec. 31, 1979 are classified as new plants.

Table VI.3.2
Integrated iron and steel Plants -- emission limits for particulate matter (mg/Ncu.m.).

Process	Emission limits
a. Sintering plant	150
b. Coke oven	-
c. Blast furnace	-
d. Steel making	
during normal operation	150
during oxygen lancing	400

b,c: No limit.

Table VI.3.3
Cement plants - emission standards for particulate matter (mg/Ncu.m.).

Capacity	Protected Area	Other Areas
= < 200 tonnes/day	250	400
> 200 tonnes/day	150	250

Table VI.3.4
Fertilizer plants -- emission limits for particulate matter and fluorides.

Product	Process	Pollutant	Emission limit (mg/Ncu.m.)
Urea	Prilling tower	Particulate	50
Phosphatics	Acidification of rock phosphate	Fluorides	25
Phosphatics	Granulation, and grinding	Particulates	150 from each process

Table VI.3.5
Oil refineries - emission standards for sulphur dioxide.

Process	SO_2 emission limit
Atmospheric and vacuum distillation	0.25 kg/tonne of feed*
Catalytic cracker	2.5 kg/tonne of feed
Sulphur recovery unit	120 kg/tonne of sulphur in the feed

* Feed indicates the feed for that part of the process only.

Table VI.3.6
Minimal national standards for effluent quality for oil refineries.

Parameter	Maximum permissible concentration in mg/litre	Maximum permissible quantum in kg/1000 t of crude processed
Oil & grease	10	7
Phenol	1	0.7
Sulphide	0.5	0.35
Biochemical Oxygen Demand	15	10.5
Suspended Solids	20	14

pH shall be between 6 and 8.5

Table VI.3.7.
Guidelines for minimum stack height.

Type of plant	Pollutant	Minimum stack height (metres)*
Thermal power stations		
< 200 MW	Sulphur dioxide	14 $Q^{0.3}$ where Q=SO_2 emission in kg/hr.
200 - 500 MW	"	220
> = 500 MW	"	275
Other industrial plants	"	> = 30
All industrial plants	**Particulate matter**	**74 $Q^{0.27}$ where Q= particulate emission in tonnes/hr**

* Stack height given by the expressions for a.1 and c valid as long as it is over 30 metres.

Table VI.3.8
Calcium carbide: standards for particulate matter emissions.

Source	Emission limit (mg/Nm^3)
Kiln	250
Arc furnace	150

Table VI.3.9
Copper, lead and zinc smelting: standards for particulate matter and oxides of sulphur.

Source	Emission limit (mg/Nm^3)
Concentrator	150 for particulate matter
Smelter and converter	Off-gases must go for H_2SO_4 manufacture: no release of SO_2/SO_3 shall be permitted from the smelter or converter.

Table VI.3.10
Carbon black: standard for particulate matter.

Year of commissioning	Emission limit (mg/Nm^3)
New plants (built & commissioned after Jan 1, 1985)	250
Existing plants (before Dec 31, 1985)	150

Table VI.3.11
Aluminium: standard for fluoride and particulate matter.

Process	Standard
Calcination	250 mg/Nm^3
Smelting	1 kg (F^-)/t of Al produced and 150 mg/Nm^3 of particulate matter

Risks from nuclear power stations

Total protection of the environment has been the prime concern of the Department of Atomic Energy (DAE) right from the beginning, as evident from a directive issued in 1960 which says: "Radioactive substances and sources of radiation should be handled not only in a manner which fully ensures that no harm can come to workers in the establishment or any one else but also in an exemplary manner so as to set a standard which other organizations in the country may be asked to emulate...".

In general, it is against this background that the nuclear power industry has developed in India. The siting of power stations is considered an important issue. Not only are site related parameters such as land characteristics, seismicity, meteorology, geology and geohydrology, availability of cooling water, potential for flooding and man-induced external events (such as flying aircraft, mining and blasting activities etc.) considered, the implications of potential dangers from failure and accident are also sought to be minimized. In particular, large population centres within a radius of 30 kilometres, are avoided.

In addition, the management of gaseous/airborne, liquid and solid radioactive wastes is given due consideration. The radiation protection standards in India are derived from the recommendations of the International Commission on Radiological Protection (ICRP), which stipulate that dose equivalent limits to the public should not exceed 100 millirem per year, from all sources excluding natural back-ground radiation and medical exposures. In contrast, the natural background radiation may be 200 millirem per year or more. Taking into account these guidelines, the waste management streams are so designed that the doze quantum to the public is less than 100 millirems per year, which allows for future expansion of nuclear power capacity at the same site also.

Although it may be difficult to quantify the adverse effects of radiation on living systems, some estimates of health effects on human beings are presented in Table VI.4.1. The values given by different agencies seem to be in fair agreement. The ICRP risk estimates show that in a group of 1 million persons, each receiving 1000 millirem per year, there will be 125 cases of fatal cancers, and 40 cases of genetic abnormalities in the first two generations and 40 additional cases in all subsequent generations.

Table VI.4.1 therefore indicates the necessity of maintaining the total doze quantum

(including background radiation and from medical exposures) to substantially below the 1000 millirem per year level.

Table VI.4.1

Cancer risk fatalities (for various organs) and for birth defects per one million persons per rem.

Organ system	BEIRI 1972	UNSCEAR 1977	ICRP 1977	BEIR III 1980
Blood (Lukemia)	25	15.25	20	22
Breast	90	50	25	87
Lung	39	25.50	20	42
Thyroid	-	10	5	2 M 6 F
Bone	6	2-5	5	-
Stomach	30	10-15		15 M 17 F
Liver lower large	30	10-15	50	8
Intestine		10-15		-

BEIR: Biological Effects of Ionizing Radiation, U.S. Committee of.
UNSCEAR: United Nations Scientific Committee on the Effects of Atomic Radiation.
ICRP: International Commission on Radiological Protection.
Source: As quoted in T. Subbaratnam, Comparison of Radiological Impacts of Nuclear Fuel Cycle and Natural Background Radiation, Energy Environment Monitor, Vol. 4, No. 1, TERI, New Delhi, March 1988.

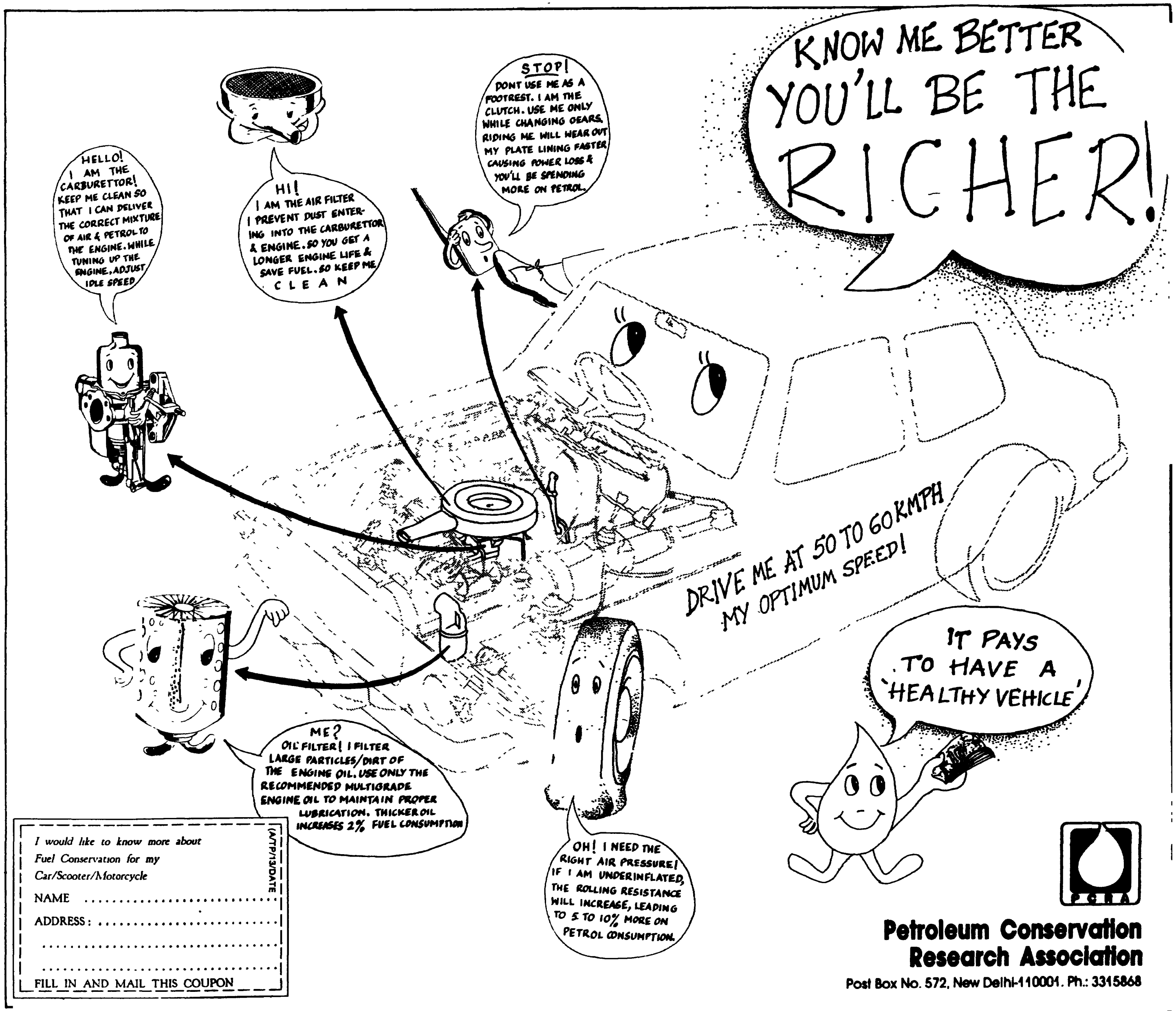
Table VI.4.2

Nuclear power and waste, 1970-89.

	No. of commercial reactors (as of Dec 31, 1988)		Net capacity of commercial reactors in MW			Spent fuel inventories		
	Operable	Under construction	Operable 1970	Operable 1988	Under construction 1988	(cumulative tons of heavy metal)		(kg per ha)
						1970	1988	1988
World	**429**	**105**	**15471**	**310822**	**84871**	**n.a.**	**n.a.**	**n.a.**
North & Central America	126	15	6433	107458	13337	151	28606	n.a.
Canada	18	4	22	12185	3524	96	11000	11.9
United states	108	7	6411	95273	7689	55	17606	19.2
South America	3	2	0	1561	1937	0	0	n.a.
Argentina	2	1	0	935	692	0	n.a.	n.a.
Brazil	1	1	0	626	1245	0	n.a.	n.a.
Asia	59	26	1658	40726	18131	0	7200	n.a.
India	6	8	400	1154	1760	n.a.	n.a.	n.a.
Japan	38	12	1258	28253	10931	n.a.	5600	148.7
Korea, Rep.	8	1	0	6270	900	0	700	71.3
Europe	183	36	5942	125402	30236	0	55100	n.a.
Belgium	7	0	0	5480	0	0	700	84.6
Finland	4	0	0	2310	0	n.a.	400	13.1
France	55	9	1190	52588	12245	n.a.	12700	230.9
Germany, F R	23	2	328	21491	1520	n.a.	3300	135.1
United Kingdom	40	2	3402	11921	1833	n.a.	30900	1279.0
U.S.S.R	56	26	1438	33823	21230	n.a.	n.a.	n.a.

Source: World Resources Institute, 1990.

Greenhouse effect and global warming


KNOW ME BETTER YOU'LL BE THE RICHER!
HELLO! I AM THE CARBURETTOR! KEEP ME CLEAN SO THAT I CAN DELIVER THE CORRECT MIXTURE OF AIR & PETROL TO THE ENGINE. WHILE TUNING UP THE ENGINE, ADJUST IDLE SPEED
HI! I AM THE AIR FILTER I PREVENT DUST ENTERING INTO THE CARBURETTOR & ENGINE. SO YOU GET A LONGER ENGINE LIFE & SAVE FUEL. SO KEEP ME CLEAN
STOP! DONT USE ME AS A FOOTREST. I AM THE CLUTCH. USE ME ONLY WHILE CHANGING GEARS. RIDING ME WILL WEAR OUT MY PLATE LINING FASTER CAUSING POWER LOSS & YOU'LL BE SPENDING MORE ON PETROL.
DRIVE ME AT 50 TO 60 KMPH MY OPTIMUM SPEED!
ME? OIL FILTER! I FILTER LARGE PARTICLES/DIRT OF THE ENGINE OIL. USE ONLY THE RECOMMENDED MULTIGRADE ENGINE OIL TO MAINTAIN PROPER LUBRICATION. THICKER OIL INCREASES 2% FUEL CONSUMPTION
OH! I NEED THE RIGHT AIR PRESSURE! IF I AM UNDERINFLATED, THE ROLLING RESISTANCE WILL INCREASE, LEADING TO 5 TO 10% MORE ON PETROL CONSUMPTION.
IT PAYS TO HAVE A 'HEALTHY VEHICLE'

The greenhouse effect and global warming

Introduction

Four principal gases (nitrogen, oxygen, argon and carbon-dioxide) constitute about 99.997% of the atmosphere (excluding water vapour); other gases (neon, methane, krypton, helium, xenon, hydrogen, carbon-monoxide, nitrous oxide, nitrogen dioxide, sulphur dioxide, radon and ozone) are present in trace concentrations.

Atmospheric concentration of greenhouse gases such as CO_2, water vapour and methane play a crucial role in regulating the heat balance of the Earth. These gases allow the incoming solar radiation (in the short wavelength range) to pass through the atmosphere, while they absorb and partially trap the low energy radiation (in the long wavelength range) by the earth's surface and re-radiate it back towards the earth. This "greenhouse" like phenomenon warms the lower atmosphere.

If the atmosphere were transparent to the outgoing long wave radiation emanating from the earth's surface, the equilibrium mean temperature of the earth's surface would be considerably cooler and probably below the freezing point of water. According to one estimate, in the absence of natural concentrations of GHGs, the earth would be on an average -19°C instead of the present value of 15°C, and the earth would be a frozen, lifeless planet.

In this context, it is clear that the mere incidence of GHG in the atmosphere itself is no cause for concern. What is important is that their concentration levels stay within reasonable limits so that global ecosystems are not unduly affected. A rise in atmospheric concentration of GHGs has led to an upward trend in global temperature. As the climate begins to warm, various processes act to amplify (through positive feedbacks) and reduce (through negative feedbacks) the warming. Some of the main feedbacks are due to changes in water-vapour, sea-ice clouds and the oceans. The 3- dimensional mathematical models of the climate system atmosphere-ocean-ice-land that take these feedbacks into account without including the GHG feedbacks are known as General Circulation Models (GCMs) These models synthesise the knowledge of the physical and dynamical processes in the overall climate system and allow for the complex interactions between various components. Some of the GCM predictions are illustrated below:

Table VII.2.1

GCM predictions of globally averaged climate change due to $2xCO_2$.

Model	Surface air temperature increase (°C)	Precipitation increase (%)
GFDL	4.0	8.7
GISS	4.2	11.0
NCAR	3.5	7.1
OSU	2.8	7.8
UKMO	5.8	15.8

GISS Goddard Institute for Space Studies, New York.
GFDL Geophysical Fluid Dynamic Laboratory of NOAA, at Princeton.
OSU Oregon State University, Cornvallis.
NCAR National Centre for Atmospheric Research
UKMO UK Model
Source: National Climate Program Office, NOAA 1989.

Table VII.2.2

Change in climatic parameters over the Indian region as demonstrated by GCM simulations for doubling CO_2 scenario.

Climatic parameters	Models		
	GFDL	GISS	NCAR
		DJF(winter)	
Temperature	Increase 3-4°C	Increase 3-4°C	Increase -2°C
Precipitation	Slight (<1 mmd^{-1}) decrease in north and increase in south	Increase 1-2 mmd^{-1}	Increase of 1-2 mmd^{-1} in north and 1 mmd^{-1} decrease in south
Soil water	Decrease < 1 cm	Decrease < 1 cm	Increase 1-2 cm
		JJF(monsoon)	
Temperature	Increase 2°C	Increase 1-2°C	Increase 2°C
Precipitation	3 mmd^{-1} increase mainly over East India	1 mmd^{-1} decrease	1-2 mmd^{-1} increase
Soil water	Slight increase	Slight decrease except in high northern latitudes	Slight increase except a slight decrease in Himalayan belt

Source: Indian Institute of Tropical Meteorology, Global Climatic Change: Regional Scenario over India, D.R. Sikka and G.B. Pant 1991

Considerable uncertainty is attached to the predictions of climate changes which is reflected in the range of values given. These uncertainties arise from

- poorly understood ocean circulation processes;
- lack of knowledge on cloud formation and feedbacks;
- crudely formulated hydrological processes;
- coarse spacial resolution; and
- inability to simulate current regional climates realistically.

GHG Concentrations

It is reported that the atmospheric concentrations of several GHGs are increasing as a result of human activities, at rates ranging from 0.5 percent per year for carbon dioxide to 4 percent or more for certain chlorofluorocarbons (CFCs).

The atmospheric concentration of carbon dioxide has increased by about 25% since about 1850 (the beginning of industrialization). The combustion of fossil fuels, deforestation, biomass burning and to a lesser extent, manufacture of cement, have contributed to the observed increases in carbon dioxide concentrations. Future emissions however, will depend mainly on the amount of fossil fuels burned.

Methane concentration has been increasing at about 1% annually over the past years as a result of agricuitural activities (cattle, rice cultivation), coal mining and fossil fuel combustion and perhaps, other sources. The concentration of nitrous oxide is also increasing at about 0.2-0.3% per year as a result of microbial activity, agricultural activities, and fossil fuel use.

CFCs are presently used as propellants, refrigerator fluids, solvents and foaming agents and they cause the depletion of stratospheric ozone. Several nations have recently decided to reduce CFC emissions. In contrast to the depletion of stratospheric ozone, the concentration of tropospheric ozone has been increasing as a result of increases of concentrations of methane and other air pollutants such as carbon-monoxide and nitrogen oxides which catalyse the conversion of oxygen to ozone. This has significant health effects.

Many of the GHGs which induce tropospheric warming through the greenhouse effect are highly stable and may be retained in the atmosphere for decades or even a century or more. While the role of carbon-dioxide in global warming is substantial, the other GHGs are 1000 to 10,000 times more effective, and are consequently dangerous even at their present trace concentration levels.

Table VII.2.3

Synopsis of information on key GHGs.

Gas	CO_2	CH_4	CFC-11	CFC-12	N_2O
Atmospheric concentration	ppmv	ppmv	pptv	pptv	ppbv
Pre-industrial 1750-1850	280	0.8	0	0	288
Present day 1990	353	1.72	280	484 310	
Current rate of change/yr	1.8	0.015	9.5	17	0.8
Lifetime (atmospheric) (yrs)	(50-200)[@]	10	65	130	150

ppmv parts/million by vol.

ppbv parts/billion by vol.

pptv parts/trillion by vol.

[@] The way in which CO_2 is absorbed by the oceans & biosphere is not simple, hence can't be given a single value.

Source: IPCC, Scientific Assessment, 1990.

Table VII.2.4

Indian emissions of CO_2 and CH_4 compared to global emissions.

GHG	India	World	% of world
CO_2 (Tg C/yr)	133	5893	2.3
(fossil fuel sources only)	(1988)	(1988)	
CH_4 (Tg CH_4/yr) (livestock + rice paddies)	10	190	5.0

Source: CSIR, A preliminary report on 'Global Change: Greenhouse Gas Emissions in India', A.P. Mitra, June 1991.

Table VII.2.5
Estimated sources & sinks of Methane.

	Annual release ($Tg\ CH_4$)	**Range ($Tg\ CH_4$)**
Source		
Natural wet lands (swamps, bogs, etc.)	115	100-200
Rice paddies	110	25-170
Enteric fermentation (animals)	80	65-100
Gas drilling, venting, transmission	45	25- 50
Biomass burning	40	20- 80
Termites	40	10-100
Landfills	40	20- 70
Coal mining	35	19- 50
Oceans	10	5- 20
Freshwater	5	1- 25
CH_4 Hydrate distribution	5	0-100
Sinks		
Removal by soils	30	15- 45
Reaction with OH in the atmosphere	500	400-600
Atmospheric increase	44	40- 48

Source: IPCC, Scientific Assessment, 1990.

Table VII.2.6

Estimated sources and sinks of Nitrous Oxide.

	Range (TgN per Yr)
Source	
Oceans	1.4-2.6
Soils (tropical forests)	2.2-3.7
(temperate forests)	0.7-1.5
Combustion	0.1-0.3
Biomass burning	0.02-0.2
Fertilizer(incl. ground water)	0.01-2.2
Total	**4.4-10.5**
Sinks	
Removal by soils	
Photolysis in the stratosphere	7-13
Atmospheric increase	3-4.5

Source: IPCC, Scientific Assessment, 1990.

Table VII.2.7

Estimated sources and sinks of carbon dioxide.

	Range (TgC per Yr)
Source	
Ocean	102700-106500
Land	8700-120000
Fossil fuel	4500-5500
Land use conversion	0-2600
Sinks	
Oceans	106000-108000
Land	100000-140000

Source: Deptt. of Energy, United States, "A Primer On GHGs"

Table VII.2.8

Estimates and projections of annual anthropogenic emissions of GHGs from agriculture, forestry and waste management activities.

	1985			2020-2025		
	CO_2 (BT-C)	CH_4 (MT-CH_4)	N_2O (BT-C)	CO_2 (MT-CH_4)	CH_4 (MT-N)	N_2O (MT-N)
Land use changes (incl. deforestation)	1.0-2.0	50-100	--	1.1-3.9	50-100	--
Biomass burning	3.9	20-80	0.2	--	--	--
Soils (incl. soil organic matter)	0-2	--	2.9-5.2	--	--	--
Animal systems	--	65-100	--	--	170-205	--
Rice cultivation	--	25-170	--	--	100-210	--
Nitrogen fertilizers	--	--	0.01-2.2	--	--	--
Waste management	--	20-70	--	--	50-90	--
Total annual anthropogenic emissions from all sources (incl. energy use)	**6**	**540**	**12**	**12**	**760**	**16**

Notes: 1. Land use changes and biomass burning estimates overlap and are not additive.
2. A recent preliminary report on tropical deforestation (Myers, 1989) estimates emission from deforestation to be 2.0 - 2.8 BT-C per year for 1989, with a mean working figure of 2.4 BT-C. 3. CH_4 can be expressed as tonnes carbon by multiplying CH_4 estimate by 0.75.

Source: IPCC Working Group I Final Report, Summer 1990; IPCC AFOS Tropical Forestry Workshop, Sao Paulo, 1990; Andreae, 1990; IPCC-AFOS Agriculture Workshop, Washington, 1990..

Table VII 2.9

CH_4 emissions from rice fields in India.

Site	Soil type	Concentration in ppm	Efflux $mg/m^2/hr$	Period
New Delhi	Sandy loam pH 6.5-8.0	1.5-2.1	0.5-4.5	Sept. 89
Dehradun (U.P.)	Sandy clay loam pH 6.0-6.5	1.65-2.24	0.02-0.31	Oct. 89
Karnal (Haryana)	Inundated loam pH 8.0-8.5	1.63-2.71	1.34-67.99	Oct. 89
Nadia (West Bengal)	Low lying puddled sandy loam pH 8.2-8.35	1.65-5.50	2.90-8.60	Aug. 86

Source: National Physical Laboratory, Diurnal variation and soil dependence of CH_4 efflux from rice paddy fields in India, Parashar et al.

Consequences of enhanced greenhouse effect and global warming

The climate is naturally subject to changes and fluctuations. The enhancement of the greenhouse effect has reached a level at which the anthropogenic increases in GHGs have the potential to affect the global climate. The projected changes in climate pose a serious threat to natural terrestrial ecosystem and the associated socio-economic systems. The possible changes in environment are as follows:

- The most direct effect of increased trapping of heat radiation is global warming. The magnitude and rate of expected warming cannot be predetermined accurately. Theoretically based global climatic models (GCMs) indicate that the mean surface temperature may increase by 1.5 to 4.5^{0}c within the next century, the changes becoming significant in the next few decades;
- The exact geographic distribution of the predicted warming is uncertain but will differ between geographic regions and may vary with seasons. Available analyses suggest that warming will be less pronounced in the tropics and more in the higher latitudes;
- As a result of altered temperature gradients, the patterns of winds, storm activity, precipitation and evaporation will change. The warming trend is likely to result in overall increase in both evaporation and rainfall. Owing to the variable patterns of atmospheric circulation, some locations may become wetter, as rainfall increase exceeds potential evapotranspiration, while other locations (interior of continents) may become drier;
- The overall warming trend may increase the frequency and the severity of climatic extremes such as heat waves, torrential storms, droughts etc. Such extreme events may affect the environment to an even greater degree than is indicated by the

simple change in the mean values of these usual climatic variables;

- Global warming is also likely to cause melting of glaciers and thermal expansion of sea water resulting in sea level rise. According to the IPCC, Business as usual scenario in 2030, the mean sea level rise is expected to be 8-29 cm above present day levels, with a best estimate of 18 cm. This rise will increase the hazards and flooding in low-lying coastal areas, river deltas and estuaries, wetlands and drainage outlets. Salt water intrusion into fresh-water lagoons and aquifers may also occur. The effects of sea level rise include:

  (a) loss of land and human habitations. Island states are particularly vulnerable to sea level rise as it could lead to partial or total submergence;

  (b) penetration of salt into drinking and agriculture water supplies;

  (c) beach erosion;

  (d) loss of wetland and wildlife habitat; and

  (e) warmer temperatures in the estuaries could prove to be harmful. The sensitive birds inhabiting such places would experience an increased rate of body metabolism which calls for more oxygen. As these areas are already low in oxygen in summers, the survival of this species of animals may be threatened.

- Greater intensity of tropical storms which will penetrate further inland due to sea level rise, resulting in greater loss of life, property and ecosystem.
- Global warming and associated climatic changes will bring about depletion of stratospheric ozone layer and increase in tropospheric ozone, among other effects.

Potential effects of global climate change on various sectors

The above changes in the global atmosphere are likely to affect the natural terrestrial ecosystem and this could have socio-economic implications. The particular areas that are expected to feel the strain include:

- *Human health*: increased levels of damaging ultraviolet-B (UV-B) radiation, as the stratospheric ozone layer thins out, will cause a significant rise in the occurrence of skin cancer, cataract and snow blindness (Hiller et.al. 1983). UV-B radiation also suppresses the immune defence against certain infections and tumours initiated in the skin. Each 1% decline in ozone is expected to cause a 0.3% to 0.6% increase in cataracts and 2.7% to 4.6% increase in certain types of skin cancers.
- *Human habitation*: these are likely to be vulnerable to sea-level rise, tropical cyclones, floods, drought or water shortages, loss of biomass etc.
- *Hydrology and water resources*: climate change can lead to changes in soil moisture and water resources. A change in regional precipitation is highly likely, which can not be predicted well. Higher winter temperatures may also have an impact in the transitional winter snow zones. More winter precipitation would be in the form of rain instead of snow, thereby increasing winter season runoff. The additional winter runoff cannot be stored because of flood control considerations or lack of adequate storage. The result would be a loss in usable supply.
- *Agriculture*: The most important changes of climate for agriculture which are based on GCMs include changes in climate extremes, warming in the high latitudes,

poleward advance of monsoon rainfall, and reduced soil water availability (particularly in mid-latitudes and low latitudes; IPCC, 1990). The effect of climate change on agriculture may be of three kinds:

- direct physiological effect of elevated levels of CO_2 on crop plants and weeds;
- effect of changes in climatic variables like temperature, precipitation and solar radiation; and
- effect of climate related rises in sea level on land use.

From the above, the following repercussions could be expected:

(a) Global food security could be endangered through increased soil erosion, greater shifts and uncertainties in agriculture production, particularly for many vulnerable areas.

(b) Demand for irrigation water may be expected to rise considerably due to increased aridity.

(c) Salt water intrusion into surface and groundwater could have deleterious effects on irrigation.

(d) Some development processes such as flowering have been shown to be affected by elevated CO_2. If the development process is affected, then the progress of the crop through different stages of the life cycle is altered, thus potentially shortening or lengthening the required growing period. This may lead to a change in yield.

(e) With increase in CO_2 concentration there is generally a rise in the total non-structural carbohydrate content. This change in status may affect palatability, nutritional value and storage qualities, for fruits, grains and vegetables.

(f) There could be wide ranging effects on the distribution of agricultural pests. These pests whose range is presently limited by temperature may extend their range and cause diseases. There could be mass crop loss as most agricultural diseases have greater potential to reach severe levels under warmer conditions.

(g) There could be indirect effects on agriculture through effects on other environmental processes. Changes in the intensity of rainfall may affect rates of soil erosion and desertification. As a consequence of changes in rainfall, soil fertility changes could result. This would affect crop yields. Higher rates of evapotranspiration could, in some regions, lead to more frequent spells during which top soils are dry and therefore prone to erosion by wind.

- *Natural and man-made ecosystems including biological diversity*: Apart from the effects on agriculture which would also apply to forests in a general way, this would include:

(a) climatic changes which are likely to effect the zonation and productivity of natural and man-made ecosystems;

(b) a warmer regime which will disrupt the adaptation of flora and fauna to their existing locations;

(c) rate of climatic change may be too rapid to allow some biotic communities to adjust; and as the evolving climate becomes unfavourable, large forest areas may die down;

(d) increased flooding and water-logging in some areas and increased aridity in others, which could devastate currently productive biotic communities;

(e) removal of permafrost which could dry out the tundra;

(f) sea level rise which could devastate coastal ecosystems;

(g) terrestrial ecosystems which may move towards the poles in response to warming. However, the rate of warming may exceed the ability of ecosystems to migrate (or corridors for migration may not be available). Consequently, a loss of species, or a reduction in numbers at least can be expected;

(h) associated species including wildlife that depend on forest ecosystems may be threatened with extinction. In this manner, climatic change will result in loss of biodiversity in general, and endanger vulnerable species in particular;

(i) in some areas however, forests may expand because of warming. In some other areas, there may be increased productivity of forests due to carbon-dioxide fertilisation effects, i.e. increased photosynthesis. This is open to question because it is not certain that increasing carbon-dioxide concentrations would increase the efficient use of growth limiting inputs like water, nitrogen, phosphorus etc., in the context of a changed climate.

- *Transport*: Increased sea levels could be expected to affect transport infrastructure, such as ocean ports. Likely shifts in water levels on lakes and rivers, may affect navigation on inland waterways. Changes in frequency and seasonality of storms may affect airways, waterways, roads and railways. Some elements of transport are likely to be significantly affected by public policies or consumer actions designed to restrain emissions of GHGs.

The potential repercussions stated above are debatable as a whole lot of uncertainties are involved, particularly, given the positive and negative feedbacks which may accentuate or diminish by then with global warming.

Appendix

Energy units and conversion

Until now, energy data in India have been compiled in coal replacement units, as opposed to coal equivalent units or other units that measure the calorific content of an energy source. By using coal replacement units, one effectively compiles data on the useful energy consumed. The conversion of energy demand data into replacement units is a two-step process: (i) measuring useful energy per unit of a particular fuel in a particular end-use; and (ii) estimating the quantity of coal required to obtain the same amount of useful energy in the same end-use.

For example, consider a fuel f, of energy content x kCal/kg, used with an efficiency ef in a particular end use. To find the coal replacement value, let coal of energy content 5000 kCal/kg be used with efficiency ec in the same end use. The coal replacement can be worked out as follows:

Useful energy in kCal from 1 kg of fuel f= ef.x

Useful energy in kCal from 1 kg of coal = ec.5000

$$\text{Coal replacement unit for fuel f} = \frac{\text{ef.x}}{\text{ec.5000}} \text{ kg of coal}$$

Although the coal replacement concept is of relevance to India, where coal is the major energy source, conversion of data into coal replacement units entails some problems. It is necessary to know the end-use efficiency of each end-use device or equipment using a particular fuel, as well as an estimate of the efficiency of a device (sometimes hypothetical, as in case of automobiles using gasoline or diesel) if it were to use coal for the same end-use. Furthermore, it would be necessary to differentiate between different end-uses of various energy fuels (e.g. kerosene for lighting and cooking; or diesel use in buses or trucks). Clearly, different end-uses have seldom been recognized for computing coal replacement values. And it is difficult to get even estimates of overall average efficiencies of the various end-use equipment.

However, some estimates of coal replacement units for various fuels are presented. The calorific contents for several commercial and traditional fuels are also presented.

A problem which often confronts energy analysts relates to the attribution of a calorific value to electricity. The calorific equivalent of electricity may be measured in one of the following two ways: (i) by equating it to the calorific content of the amount of fossil fuel that is required to generate 1 kWh of electricity in conventional thermal

power stations; or (ii) by equating it to the amount of fossil fuel that has the same energy content as the theoretical maximum heating value of 1 kWh of electricity.

The results obtained from the two methods are very different; this difference reflects the fact that two-thirds or more of the energy content of the primary fossil fuel input for thermal power generation gets lost as waste heat during conversion. To generate 1 kWh of electricity with a maximum theoretical heating value of 860 kCal, even the most efficient thermal stations would require fossil fuel with an energy content of 2500 kCal/kg.

There is no theoretically correct answer regarding the choice between the two methods -- the choice in fact, depends on the purpose for which the data are used. For instance, if the issue in question relates to the investigation on the options for development of thermal or hydro-electric projects, the first method is suitable.

Table VII.1

Coal replacement units.

Soft-coke/coal	1 mt = 1.5 mtcr
Kerosene	
- for lighting	1 million Kilolitres = 2.086 mtcr
- for cooking	1 million Kilotitres = 5.623 mtcr
LPG	1 mt = 10.184 mtcr
Electricity	1000 GWh = 0.706 mtcr
Firewood	1 mt = 0.655 mtcr
Charcoal	1 mt = 1.807 mtcr
Dungcakes	1 mt = 0.301 mtcr
Crop residues	1 mt = 0.527 mtcr

Source: NCAER, Domestic Fuel Survey With Special Reference to Kerosene (1978/79), New Delhi, 1981.

Table VII.2

Calorific value of different fuels.

a. Commercial fuels	
a1 Coal	
Hard coal	5000 kCal/kg
Lignite brown coal	2310 kCal/kg
Charcoal	6900 kCal/kg
a2 Petroleum products	
LPG	10800 kCal/kg
Gasoline/naphtha	10500 kCal/kg
Kerosene	10300 kCal/kg
Jet fuel	10400 kCal/kg
Fuel oil	9600 - 9900 kCal/kg
a3 Natural gas	8000 - 9480 kCal/cu.m.
a4 Electricity	860 kCal/kWh
b. Biomass	
b1 Agricultural wastes	
Paddy straw	3000 kCal/kg
Rice husk	3440 kCal/kg
Mango leaves	3390 kCal/kg
Groundnut straw	4200 kCal/kg
Sugarcane bagasse	3800 kCal/kg
Wheat straw	3800 kCal/kg
Cotton stalks	3300 kCal/kg
Maize stalks	4700 kCal/kg
Maize cobs	3500 kCal/kg
Bajra stalks	3850 kCal/kg
Gram straw	3950 kCal/kg
Masoor straw	3810 kCal/kg
Moong straw	3980 kCal/kg
b2 Forestry residues	
Wood wastes	2500 -3850 kCal/kg
Bark	2500 - 2850 kCal/kg
b3 Animal wastes	
Cowdung	3290 kCal/kg
Cowdung cake	3140 kCal/kg

a1. Gross calorific value of coal; the useful heating values for various grades of coal are given in section II.1.

a2. Net calorific value.

b. Upper heating value; for oven dried biomass.

Source: [1] Department of Petroleum, Indian Petroleum & Natural Gas Statistics 1986-87;

[2] The World Bank, Guidelines for the Presentation of Energy Data in Bank Reports, Energy Department Paper No. 7, October 1982; and

[3] O.P. Vimal & P.D. Tyagi, Energy From Biomass, Agricole Publishing Academy, New Delhi, 1984.